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**NANO-SCALE ZERO-VALENT IRON PILOT STUDY  
NEASE CHEMICAL SITE  
SALEM, OHIO**

Prepared for:

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**1.0 INTRODUCTION**

This nano-scale zero valent iron (nZVI) Field Pilot Study Report (Report) has been prepared by Golder Associates Inc. (Golder Associates), on behalf of RÜTGERS Organics Corporation (ROC) in connection with the Pre-Design Investigation (PDI) for Operable Unit Two (OU-2) at the Nease Chemical Site, Salem, Ohio (Site). The Field Pilot Study was conducted in accordance with the nZVI Field Pilot Treatability Study Work Plan (Work Plan, Golder, 2006) that was submitted to USEPA and Ohio EPA in November 2006. The Work Plan included the results of laboratory treatability tests and field tracer testing that were conducted in preparation for the field pilot study. In addition, results of a Laboratory Biotreatability Study performed as an adjunct to the nZVI study by HydroQual Laboratories Ltd. (HydroQual), located in Calgary, Alberta Canada, are reported.

Section 2.0 of this report presents the methods and procedures used in the performance of the nZVI field pilot test, Section 3.0 presents the results of the monitoring program, Section 4.0 presents a summary of the Laboratory Biotreatability Study, and Section 5.0 presents conclusions and recommendations for full scale application.

## **2.0 NZVI FIELD PILOT TEST IMPLEMENTATION**

### **2.1 Well Configuration**

The pilot test layout included four monitoring wells located between 10 and 20 feet from a single injection well location (NZVI-3), as shown on Figure 1. NZVI-2 and NZVI-4 are located in a generally downgradient direction from NZVI-3, which was used as the injection well. The other wells are located sidegradient (NZVI-1) or upgradient (PZ-6B-U).

### **2.2 Preliminary Testing**

Slug testing conducted prior to the pilot test indicated that wells PZ-6B-U and NZVI-1 were located in locally lower hydraulic conductivity zones compared to wells NZVI-2 and NZVI-3. Table 1 presents the slug testing results, and the slug testing analyses are presented as Appendix A.

Tracer testing conducted following the slug testing indicated that NZVI-3 was the most appropriate injection well because it could accept higher rates of injection (Golder, 2006). The tracer testing also showed that NZVI-1 was located within a localized zone of lower permeability and PZ-6B-U and NZVI-2 indicated faster responses to the tracer injection.

NZVI-4 was installed as an additional well to provide adequate monitoring downgradient of NZVI-3, as shown on Figure 1. Table 1 indicates that monitoring well NZVI-4 has a relatively high hydraulic conductivity.

### **2.3 NZVI Slurry Injection**

The composition of the nZVI slurry used for the pilot study included approximately 105 kilograms of mechanically produced nZVI, 87% of which included a low level palladium catalyst at 0.1 wt.%. A slurry volume of 10,520 liters was prepared including a food-grade, organic dispersant (powdered soy, 20% by weight of nZVI quantity) pre-mixed with potable water to complete hydration prior to addition of nZVI at a concentration of 10 grams per liter. Based on production testing, the nZVI particle size overall ranged from approximately 30 nm to 1,000 nm, with most of the particle sizes falling within the 100 nm to 500 nm range.

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Injection methods, average injection rates, pressures, and quantities for the pilot test are presented in Table 2. Injection rates of 0.5 to 2 gallons per minute were obtained throughout the injection phase, which utilized both gravity feed and pressurized injection techniques. The gravity injection method with and without an in-line feed pump was used initially. The maximum injection rate achieved using this method was 1.25 gallons per minute (gpm). Using pressurized injections initially nearly doubled the rate, however higher rates (1.5 gpm to 2.0 gpm) were not sustained for more than three days. Each slurry injection event was followed by an injection of a "wash" of 5 to 20 gallons of water designed to flush the nZVI from the well screen and into the formation.

Slurry injection rates that were achieved were lower than anticipated based on the earlier tracer testing. A primary factor inhibiting the slurry injection may have been the sand pack of the injection well. Alternatively, the bedrock fractures adjacent to the sand pack may have become partially filled with iron, slowing the injection rate.

The amount of nZVI/Pd-nZVI injected at well NZVI-3 on a daily basis was also limited by field factors such as sub-freezing ambient temperatures and limited daylight. Other factors to be optimized include batch preparation time (mixing of nZVI and dispersant), injection well potable water rinse time, and operation of the injection well submersible pump and feed pump during times of sub-freezing temperatures.

### 3.0 MONITORING RESULTS

#### 3.1 Continuous Monitoring

Wells PZ-6B-U, NZVI-1, NZVI-2 and NZVI-4 were monitored continuously with downhole electronic dataloggers, beginning approximately 24 hours prior to the initial nZVI injection. The dataloggers were equipped with pressure transducers to measure water level, and sensors for dissolved oxygen (DO), oxidation-reduction potential (ORP), specific conductance (SC), pH, and temperature. Datalogger monitoring was continued for a period of two weeks following the completion of nZVI injection. Graphs of the datalogger output are included in Appendix B.

Hydraulic monitoring showed that water levels responded fairly uniformly to the injections, rising as much as 0.5 ft when injection rates were highest (whether under pressure injection or gravity fed), and rising 0.2 ft at the lower injection rates. This indicates that the injection pressure radius of influence extends well over 20 feet.

ORP was primarily used to evaluate the relative strength and transport of the nZVI slurry during injections. ORP trends indicate that favorable ORP responses were observed in all wells<sup>1</sup>. Declining trends and subsequent strongly negative ORP values were sustained up to the time the dataloggers were removed. This indicates that the extent of the diffuse reactive zone also extends for at least 20 feet.

#### 3.2 VOC and SVOC Analytical Results

Post-baseline groundwater chemistry monitoring was conducted over six monitoring events at 2 weeks, 3 weeks, 5 weeks, 9 weeks, 13 weeks, and 21 weeks after the initiation of nZVI injections (see Table 3). About 44% of the nZVI mass was injected by the first sampling round, 70% by the second round, and 100% by the end of the fifth week, prior to the third sampling round. Samples collected from all post-baseline sampling events were analyzed for TCL volatile organics (including chlorobenzene and dichlorobenzenes). Rounds 3, 5 and 6 also included analysis of semi-volatile organic compounds (SVOCs) and geochemical parameters (section 3.3) consistent with the baseline sampling event. Baseline sampling results indicated that mirex was not present

<sup>1</sup> NZVI reactions are reducing in nature, and ORP data provide the best indication of the effect of NZVI, for which significant reductions in ORP are typically observed.

In the pilot test wells and therefore mirex was not sampled in Rounds 1 to 6. The analytical results are included as Appendix C.

The sampling results for individual wells with respect to total VOCs, total chlorinated ethene compounds (Chloroethenes), PCE, TCE, cis-1,2-Dichloroethene (c-DCE), trans-1,2-Dichloroethene (t-DCE), Vinyl Chloride, and 1,1-Dichloroethene are included in Figures 2 to 6. Percentage changes of selected VOCs in each individual well are included in Figures 7 to 14.

The testing data show favorable results throughout the pilot testing monitoring network. PCE was present in the pilot test area at the highest concentrations prior to testing (10 mg/L to 85 mg/L). Reductions in PCE concentration in NZVI-4, the monitoring well immediately downgradient of the injection well, were 95% and 88% in Rounds 2 and 3, respectively, and was 52% after Round 6<sup>2</sup> (Figure 7). In the injection well, NZVI-3, a maximum reduction of 64% was observed in Round 3, and the reduction remained at 55% at Round 6. In all wells, decreases were sustained throughout all sampling rounds, with final reductions of 41% for NZVI-1, 24% for NZVI-2, and 68% for PZ-6B-U in Round 6. The trends in PCE concentrations at Round 6 were declining (2 wells), steady (2 wells) or slightly increasing (1 well).

Decreases in TCE concentrations were also observed in all wells, although NZVI-1, after initially declining, rebounded to concentrations above baseline (Figure 8). The injection and immediately downgradient well, NZVI-3 and NZVI-4 respectively, exhibited 49% and 57% reductions through Round 6. PZ-6B-U exhibited a decline of 66%.

In sum, substantial decreases in PCE and TCE concentration were observed throughout the pilot test wells, with the highest reductions observed in the injection well and proximate monitoring wells. In some cases, lower performing wells appear to correspond to the lower permeability zones. Although some rebound occurred from the maximum reductions of Rounds 2 and 3, overall reductions remained substantial by Round 6 (21 weeks). In the early rounds, the downgradient well NZVI-4 exhibited greater reductions than the injection well NZVI-3, which may be related to the daily washes which likely influenced the injection well more than the

<sup>2</sup> "Rebound" of concentrations is not unexpected; the mass of contaminant present may exceed the reactivity of the quantity of nZVI introduced during the pilot study

monitoring wells. By the end of monitoring (Round 6) the injection well exhibited similar reductions as NZVI-4.

Concentrations of breakdown products of PCE and TCE, including c-DCE and vinyl chloride, are presented in Figures 9 and 10. Increases in c-DCE concentrations were observed in four of the five pilot wells ranging between 50% and 100% (Figure 9). These c-DCE concentration rises are likely due to the reduction of PCE and TCE. A further breakdown product, vinyl chloride, was detected in only three samples at concentrations ranging from 130 ug/L to 290 ug/L (reporting limits were generally on the order of 1000 ug/L).

Results for 1,1,2,2-Tetrachloroethane (1,1,2,2-TeCa) included declines of over 40% in wells NZVI-4, NZVI-2 and PZ-6B-U, while increases of up to 90% were observed in injection well NZVI-3. Increasing concentrations of parent compounds can indicate increased dissolution of the compound from a residual phase. 1,1,2,2-TeCA may produce breakdown products along a reductive pathway of 1,1,1-TCA, 1,1-DCA, chloroethane and ethane. Other abiotic and biological breakdown pathways may produce cis-DCE, trans-DCE and 1,1,2-TCA (Vogel et al., 1987; House, 2002).

Benzene and 1,2-Dichlorobenzene concentrations are potentially related during nZVI treatment based on the potential for the creation of benzene from the reduction of 1,2-Dichlorobenzene. While one monitoring well, PZ-6B-U exhibited a decline in 1,2-Dichlorobenzene, a rise in benzene concentration was not observed.

Conclusions from the VOC monitoring include:

- PCE and TCE were substantially degraded
- 1,1,2,2-TeCA was substantially degraded in several wells
- Cis-DCE was produced, likely from the breakdown of PCE and TCE and possibly 1,1,2,2-TeCA
- Little degradation of 1,2-Dichlorobenzene or benzene was observed
- The greatest reductions occurred in the injection well and proximate monitoring wells.

### 3.3 Geochemical Analytical Results

The geochemical analytical program included light hydrocarbons (methane, ethane, ethene and acetylene), total organic carbon (TOC), sulfate, sulfide, nitrate, nitrite, total phosphate, chloride, total alkalinity, total suspended solids (TSS) and ferrous iron. Sulfide, nitrate, nitrite, phosphate, chloride, TOC and total alkalinity did not exhibit trends related to the nZVI injections. While TOC data, which was included to evaluate the soy powder footprint, indicated some correspondence to the injections [an increase over baseline (140 mg/L in Round 2 vs. 89 mg/L during baseline) was observed in the well NZVI-4], overall the data did not exhibit consistent trends. Parameters which exhibited trends associated with the injections are discussed below.

Results for the light hydrocarbons ethene, ethane, methane and acetylene are shown on Figure 14. All compounds are potential breakdown products of nZVI with chlorinated aliphatic hydrocarbons (CAHs) (Kurisu, et al. 2004). The breakdown product ethene ranged in concentration from 12 ug/L to 52 ug/L at baseline, and ranged from 14 ug/L to 530 ug/L during the pilot testing with the highest concentrations in NZVI-3 and NZVI-4, consistent with the greatest PCE and TCE reductions. Ethane was produced in higher concentrations than ethene (ranging from 390 ug/L to 5,000 ug/L) in NZVI-3 and NZVI-4, also consistent with the greatest PCE and TCE reductions. While light hydrocarbons were produced primarily in NZVI-3 and NZVI-4, all other wells showed decreases in PCE, suggesting that the breakdown of PCE in other wells was not completed during the period of the pilot study. While ethane may be produced from PCE and TCE breakdown, it is also produced from 1,1,2,2-TeCA breakdown, and this may also be a source of the higher levels of ethane observed during the pilot test. Acetylene was also produced in the highest concentrations in NZVI-3 and NZVI-4, and exhibited maximums in March 2007, two months after injections were completed. Acetylene is produced via a different mechanism (beta-elimination) from ethene or ethane (hydrogenolysis) and a transition from one process to the other may have occurred after injections were completed. Methane concentrations exhibited modest increases (e.g., from 66 ug/L to 180 ug/L in NZVI-3) which are likely related to biodegradation of the soy powder under the highly reducing conditions.

Total suspended solids (TSS) (Figure 15) can indicate the amount of nZVI present depending on the filter size, range in size of the nZVI particles injected and any agglomeration of the nZVI. TSS were analyzed prior to and after injections and showed increases in NZVI-2, NZVI-3 and NZVI-4 with the highest concentrations present immediately after injections. In addition, the

highest concentrations were observed in the injection well followed in order by more proximate/downgradient wells. NZVI-1 did not exhibit a trend associated with injections, consistent with its location within a localized low permeable zone. Based on these data, it appears that TSS can track the migration of nZVI.

Sulfate (Figure 16) exhibited consistent reductions in all wells and generally declining trends over all events following injections. Reductions in Round 6 ranged from 13% (PZ-6B-U) to 76% (NZVI-3) compared with baseline concentrations. Naturally occurring sulfate is subject to reduction by nZVI and represents a significant demand on nZVI at this site, based on the measured background concentrations of 100 mg/L to 300 mg/L.

Conclusions from the geochemical monitoring include:

- The diffuse reactive zone was over 20 foot in radial extent from the injection well based on a variety of indicators, including ORP, TSS, and sulfate.
- Light hydrocarbons (ethene, ethane, methane and acetylene) indicated stronger evidence of nZVI reactions in the injection and proximate/downgradient wells (NZVI-3 and NZVI-4), which may indicate that PCE reduction was incomplete in other wells during the period of the pilot test.
- Ethene and ethane were generated with ethane produced in higher concentrations from the breakdown of PCE, TCE and 1,1,2,2-TeCA.
- Acetylene was also produced, likely via a different reaction pathway, after injections were completed.
- TSS can potentially be used to track the presence of nZVI, depending on the range in size of the nZVI particles.
- Naturally occurring sulfate levels present a significant background demand for nZVI at the site.

#### **4.0 LABORATORY BIOTREATABILITY STUDY**

Consistent with the Work Plan, a laboratory biotreatability study was conducted to evaluate the potential for biological treatment as an adjunct to the nZVI treatment to address residual contaminants such as benzene. The bench-scale nZVI study performed prior to the field pilot test showed treatment of the chlorinated aliphatic hydrocarbons (CAHs) and chlorinated benzenes; however, benzene was not treated in the bench-scale nZVI study.

##### **4.1 Objectives**

The current laboratory biotreatability study evaluates groundwater that has been fully treated by nZVI, similar to the expected conditions after the nZVI portion of the remedy has been fully implemented and groundwater from outside the pilot test area (monitoring well D-12) for comparison purposes.

The primary objectives for the Study were to assess the:

- “Biological signature” (i.e., the presence and types of microflora) of groundwater that has not been treated with nZVI
- Influence of the soy powder dispersant used in the pilot test on the biological signature of groundwater not treated with nZVI
- Biological signature of groundwater after nZVI treatment
- Intrinsic biodegradation potential of benzene in the groundwater after nZVI treatment
- Biodegradation potential after nZVI treatment through stimulation of populations of benzene-degrading bacteria.

##### **4.2 Methodology**

Groundwater samples used for this study were obtained from nZVI pilot test well nZVI-4 and from monitoring well D-12, located outside of the Pilot area in the vicinity of Pond 1 and Pond 2. Well nZVI-4 was chosen due to the presence of the greatest reductions in VOCs observed in the pilot testing. Well D-12 was chosen for analysis to evaluate bacteria populations in impacted groundwater from the same hydrostratigraphic unit that had not been treated with nZVI. The

Study involved a preliminary analysis phase followed by two (2) sequential test phases that were run concurrently.

#### 4.3 Results

Detailed results of the study are presented in the laboratory report prepared by HydroQual that is included as Appendix D. Overall, the results suggest that intrinsic anaerobic biodegradation of benzene is occurring, albeit slowly and that the addition of a suitable electron acceptor (e.g., nitrate or sulfate) may enhance the biodegradation rate. Using nitrate as an amendment appears to be most successful at enhancing the biodegradation of benzene while having the least amount of impact on the already functioning CAH degradation. The treatments with nitrate were moderately successful in that benzene decreased 66% in 2 months when the groundwater was amended with nitrate and nZVI, and benzene decreased 26% in 2 months with soy powder, nitrate, and nZVI. It is likely that degradation rates were lower when soy protein was present due to competition of the soy with benzene as the electron donor for microorganisms. Treatments with sulfate showed a 31% decrease in benzene with sulfate and nZVI and a 51% decrease with sulfate, nZVI, and soy powder. There appeared to be no correlation between a decrease in benzene and an increase in any particular species of bacteria.

Along with assessing the biotreatability of benzene, the study also sought to better understand the biological impact of nZVI treatment. Results suggest that the impact of nZVI and soy protein on indigenous microorganisms is limited. The addition of nZVI limits the total amount of DNA present (i.e., limits the total biomass), but does not significantly affect diversity. This is consistent with nZVI acting as a stressor for microorganisms as geochemical conditions are significantly altered by its presence, but overall nZVI produces highly reducing conditions that enhance biodegradation of CAHs. Soy protein also appears to act as an efficient electron donor in the system further stimulating anaerobic biodegradation. The addition of soy protein limits the diversity of microorganisms to one (1) singular species or similar species in the short term, but bacterial populations rebound relatively rapidly (approximately 1 to 2 months) to pre-addition diversity levels. This is consistent with soy protein acting as a readily available carbon source which stimulates the growth of specific opportunistic species potentially at the expense of others. This impact appears to be locally isolated and limited in duration and does not pose a significant long-term risk to indigenous microorganisms.

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In the context of the study objectives, the following major conclusions can be drawn:

- The “biological signature” (i.e., the presence and types of microflora) of groundwater that has not been treated with nZVI is abundant and diverse and is not impacted by the concentrations of CAHs or chlorinated benzene compounds present. There is no significant difference in the microbial abundance or diversity between water from monitoring well D-12 and nZVI-4 suggesting that the impact of nZVI injection does not persist long-term.
- The influence of the soy powder dispersant used in the pilot-test on the biological signature of groundwater not treated with nZVI was significant and resulted in the predominance of one (1) singular species. This impact was short-term and only persisted for approximately 1 to 2 months before returning to pre-addition conditions.
- The biological signature of groundwater after nZVI treatment, in particular nZVI treatment alone (without soy) is typified by a generally lower concentration of DNA but a similar diversity.
- Biodegradation after nZVI treatment can be enhanced through stimulation of populations of benzene-degrading bacteria through nitrate or sulfate addition. It is anticipated that nitrate addition will have greatest impact after nZVI reactivity has ceased and CAH treatment has been completed. Competition between added electron acceptors (sulfate and nitrate) for electrons generated by nZVI could be a significant issue for maintaining adequate electron acceptor concentrations to promote biodegradation.

## 5.0 DESIGN CONSIDERATIONS

### 5.1 nZVI Design Layout

The pilot test has provided information on several design factors, including:

- The hydraulic radius of influence and diffuse reactive zone based on ORP data and other was found to significantly exceed the 20-foot well spacing of the pilot test network;
- During the period of the pilot test (21 weeks), nZVI based reductions in CAHs were found to be similar in the injection and two wells at distance of 10 feet and 19 feet;
- nZVI based reductions in CAHs were not uniform in all wells during the period of the pilot test. This may be due to the influence of a low permeability zone;
- Reaction longevity (PCE reductions remained at 50% or greater for 21 weeks);
- Geochemical influences;
- Well design; and,
- Well spacing.

The pilot test results suggest that the full scale well design should incorporate features designed to increase the injection flow rate. Full-scale wells will be of open-hole design (rather than using a sand pack which may cause clogging) and will allow for overdrilling of the open hole portion so that if clogging of the fractures on the inner surface of the borehole is suspected, it may be removed by overdrilling. Supplementary testing of this alternate well design is considered appropriate prior to installation of all injection wells.

Given the relatively short duration of the test, the well spacing of the pilot wells was limited to 20 feet. Influence was shown to extend to at least this radius and so a design well spacing of 80 feet, as used in the FS, is still considered appropriate. The influence of wells in the full-scale system will be expanded due to both the extended time period and the potential for multiple injection events. Intermediate monitoring wells will be part of the full-scale design and it is recommended that such wells be capable of retrofitting to serve as injection wells, if necessary.

Complete reduction of all chlorinated compounds was not achieved in the period of the pilot test and therefore multiple injections will be planned (as provided for in the FS (Golder, 2004)).

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Quarterly injections are envisioned based on the longevity of the reductions observed in the pilot test (greater than 21 weeks).

## 5.2 Potential Biological Phase Treatment

A significant design consideration for this remedial action is the phasing of each portion of the treatment, i.e. treatment of CAHs (Phase I) and treatment of benzene (Phase II). CAH dechlorination proceeds through an abiotic series of chemical reactions through direct contact with nZVI particles; however, there is also a co-existing pathway for enhanced biodegradation due to the reducing conditions provided by the presence of nZVI (e.g., ORP values as low as -400 mV). In the absence of additional carbon sources (electron donors), benzene may be utilized as an electron donor in the biologically mediated CAH dechlorination reactions. Microorganisms will extract electrons from benzene, generating CO<sub>2</sub> as a by-product, and couple this oxidation to the reduction of CAHs (electron acceptors). During the pilot-scale nZVI study soy protein was used as a dispersant to maintain the nZVI particle slurry and to enhance particle mobility. Moreover, soy protein is also a readily available electron donor and may limit the use of benzene as the preferred electron donor. Final design of the nZVI program could therefore include a more limited use, or replacement, of soy protein as a dispersant so as to potentially enhance the intrinsic biodegradation of benzene during nZVI treatment.

The pilot-study suggested that chlorinated benzenes may be dechlorinated through abiotic reaction pathways with nZVI leaving the reaction product benzene. Degradation of benzene under the anaerobic conditions provided by nZVI treatment by electron acceptor amendment (e.g., sulfate or nitrate) has been evaluated. Data suggests that any residual nZVI may preferentially utilize these amendments over their use by indigenous microorganisms to degrade benzene. Therefore, a sequential treatment will be required, which consists of treatment first using nZVI (with limited carbon addition) to address CAHs, chlorinated benzenes and potentially benzene (as electron acceptor). This phase of treatment should continue until progress monitoring indicates that geochemical conditions have rebounded to pre-injection conditions indicating that nZVI reactivity has been fully utilized. At this point, the second phase of treatment would begin involving the addition of electron acceptors (sulfate or nitrate) to stimulate the degradation of remaining benzene.

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**6.0 CONCLUSIONS AND RECOMMENDATIONS**

The nZVI Field Pilot Test was completed in accordance with the nZVI Field Pilot Treatability Study Work Plan (Golder, 2006). The activities performed consisted of baseline sampling, nZVI and palladized nZVI injection, and six rounds of sampling over a twenty-one (21) week period from the start of injections. The sampling results indicated the reduction in concentrations of VOCs due to the effect of nZVI in remediating the target compounds.

A laboratory Biotreatability Study was also completed and indicated that enhanced biological degradation of benzene can be accomplished as a "polishing step."

Based on the results of these tests, the objective of providing treatment throughout the impacted area is achievable. Consistent with the approved work plan, a full-scale nZVI application with a subsequent biological polishing step is recommended to achieve the objectives of the Record of Decision.

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**TABLE 1**  
**RESULTS OF SLUG TESTING OF NZVI PILOT TEST WELLS**  
**RUTGERS ORGANICS - SALEM OHIO**

<b>Well</b>	<b>Test Type</b>	<b>Hvorslev</b>		<b>Bouwer</b>		<b>Geometric Mean</b>	
		<b>cm/sec</b>	<b>ft/day</b>	<b>cm/sec</b>	<b>ft/day</b>	<b>cm/sec</b>	<b>ft/day</b>
NZVI-1	Rising	2.82E-04	0.80	2.48E-04	0.70	2.7E-04	0.77
NZVI-1	Falling	3.29E-04	0.93	2.36E-04	0.67		
NZVI-2	Rising	4.87E-03	13.8	3.38E-03	9.57	2.6E-03	7.3
NZVI-2	Falling	1.82E-03	5.16	1.45E-03	4.10		
NZVI-3	Rising	1.97E-03	5.59	1.48E-03	4.20	1.8E-03	5.2
NZVI-3	Falling	2.39E-03	6.77	1.64E-03	4.64		
NZVI-4	Rising	1.18E-02	33.49	1.32E-02	37.33	1.3E-02	37.29
NZVI-4	Falling	1.47E-02	41.57	1.31E-02	37.21		
PZ-6B-U	Rising	5.30E-04	1.50	4.04E-04	1.14	4.9E-04	1.4
PZ-6B-U	Falling	5.83E-04	1.65	4.50E-04	1.27		
PZ-6B-M	Rising	3.73E-05	0.1	4.51E-05	0.1	4.2E-05	0.1
PZ-6B-M	Falling	4.11E-05	0.12	4.51E-05	0.13		
PZ-6B-L	Rising	1.02E-04	0.29	1.09E-04	0.31	1.1E-04	0.30
PZ-6B-L	Falling	1.02E-04	0.29	1.09E-04	0.31		

**TABLE 2**  
**SUMMARY OF NZVI INJECTIONS**  
**NEASE CHEMICAL SITE**  
**SALEM, OHIO**

Date	Injection Method	Injection Pressure (psi)	Average Injection Rate (gallons per minute (GPM))	NZVI/Pd (KG)	NZVI (KG)	NZVI Slurry (gallons)
11/28/2006	Gravity w/ pumping - open system	NA	0.6	5	-	132
11/29/2006	Gravity w/ pumping - open system <sup>1</sup>	NA	0.9	6	-	159
11/30/2006	Gravity w/ pumping - open system <sup>2</sup>	NA	0.5	1.5	-	40
12/1/2006	Gravity w/ pumping - open system	NA	<0.5	3	-	79
12/2/2006	Gravity - open system <sup>3</sup>	NA	1	4.3	-	114
12/4/2006	Gravity - open system <sup>3</sup>	NA	1.25	1.9	-	50
12/5/2006	Gravity - open system <sup>3</sup>	NA	0.3	3.4	-	90
12/6/2006	Gravity - closed system <sup>4</sup>	4	1	1.9	-	50
12/7/2006	Gravity - closed system <sup>5</sup>	NA	0.46	2.6	-	70
12/8/2006	Pressure Injection - closed system	11	2	4.5	-	120
12/9/2006	Pressure Injection - closed system <sup>6</sup>	8	1.54	6.4	-	170
12/10/2006	Pressure Injection - closed system <sup>6</sup>	NA	1.5	1.1	-	30
12/11/2006	Pressure Injection - closed system <sup>6</sup>	NA	0.77	6.4	-	170
12/12/2006	Pressure Injection - closed system <sup>7</sup>	5-19	0.6	4.3	-	115
12/13/2006	Pressure Injection - closed system	5-25	0.7	5.5	-	145
12/14/2006	Pressure Injection - closed system <sup>8</sup>	15-19	0.36	4.9	-	130
12/15/2006	Gravity - closed system <sup>4</sup> (over night)	NA	0.07	2.07	-	55
12/15/2006	Pressure Injection - closed system <sup>8</sup>	17	0.44	4.54	-	120
12/16/2006	Pressure Injection - closed system <sup>9</sup>	10-16	0.15	1.89	-	50
12/18/2006	Pressure Injection - closed system <sup>9</sup>	3-10	1.3	3	-	80
12/19/2006	Pressure Injection - closed system <sup>10</sup>	7-12	0.95	11.72	-	310
12/20/2006	Pressure Injection - closed system	10	0.73	5.67	-	150
		14	0.60	-	2.27	60
12/21/2006	Pressure Injection - closed system	14	0.69	-	10.96	290
<b>TOTAL =</b>			<b>91.7</b>	<b>13.2</b>	<b>2,779</b>	

**Notes:**

- <sup>1</sup> - Installed a 6-foot extension on the well head to increase hydraulic pressure.
  - <sup>2</sup> - The 6-foot extension was reduced to 2-feet.
  - <sup>3</sup> - Direct gravity injection from the mixing tank to the injection well.
  - <sup>4</sup> - Direct gravity injection from the mixing tank to the injection well in a closed system.
  - <sup>5</sup> - Direct gravity injection from the mixing tank to the injection well in a closed system. Note: pressure gauge was not working.
  - <sup>6</sup> - Pressure injection. Maintained a lower pressure due to leak observed in the pressure assembly.
  - <sup>7</sup> - Pressure injection. Repairs were made to the system. A lower pressure was maintained for a while in order to check the system.
  - <sup>8</sup> - Pressure injection. Maintained steady pressure. Flow rate started at 1 gpm and steadily declined throughout the injection period.
  - <sup>9</sup> - Pressure injection. Continued to observe a decline in the injection rate. The system was checked and it was determined that there was a problem with the valve. On December 18, the valve was repaired, a new recirculation pump was installed and the well was redeveloped.
  - <sup>10</sup> - Pressure injection. 185 gallons injected in the morning at an average injection rate of 1.23 GPM with an average pressure of 7 PSI. 125 gallons injected in the afternoon at a average injection rate of 0.7 GPM with an average pressure of 12 PSI.
- Note: Groundwater sampling was performed on December 19. The dataloggers were removed prior to sampling. Once sampling was completed the dataloggers were recalibrated prior to placing them back into each well.

**TABLE 3**  
**NZVI PILOT STUDY GROUNDWATER MONITORING PROGRAM SUMMARY**  
**RÜTGERS ORGANICS CORPORATION**  
**NEASE SITE, SALEM, OHIO**

Pre-Injection Groundwater Monitoring	Well ID	Parameters Analyzed			
		VOCs <sup>(1)</sup>	SVOCs	Mirex <sup>(4)</sup>	NAP/Geochem <sup>(2)</sup>
<b>Baseline (September 2006)</b>	PZ-6B-U	X	X	X	X
	PZ-6B-M	X	X	X	X
	PZ-6B-L	X	X	X	X
	NZVI-1 <sup>(3)</sup>	X	X	X	X
	NZVI-2 <sup>(3)</sup>	X	X	X	X
	NZVI-3 <sup>(3)</sup>	X	X	X	X
	NZVI-4 <sup>(3)</sup>	X	X	X	X
<b>Injection Groundwater Monitoring<sup>(5)</sup></b>	<b>Well ID</b>	Parameters Analyzed			
<b>Round 1 - December 12, 2006</b>	PZ-6B-U	X			TOC only
	NZVI-1 <sup>(3)</sup>	X			TOC only
	NZVI-2 <sup>(3)</sup>	X			TOC only
	NZVI-3 <sup>(3)</sup>	X			TOC only
	NZVI-4 <sup>(3)</sup>	X			TOC only
<b>Round 2 - December 19, 2006</b>	PZ-6B-U	X			TOC only
	NZVI-1 <sup>(3)</sup>	X			TOC only
	NZVI-2 <sup>(3)</sup>	X			TOC only
	NZVI-3 <sup>(3)</sup>	X			TOC only
	NZVI-4 <sup>(3)</sup>	X			TOC only
<b>Post-Injection Groundwater Monitoring<sup>(5)</sup></b>	<b>Well ID</b>	Parameters Analyzed			
<b>Round 3 - January 4, 2007</b>	PZ-6B-U	X	X		X
	NZVI-1 <sup>(3)</sup>	X	X		X
	NZVI-2 <sup>(3)</sup>	X	X		X
	NZVI-3 <sup>(3)</sup>	X	X		X
	NZVI-4 <sup>(3)</sup>	X	X		X
<b>Round 4 - January 31, 2007</b>	PZ-6B-U	X			TOC only
	NZVI-1 <sup>(3)</sup>	X			TOC only
	NZVI-2 <sup>(3)</sup>	X			TOC only
	NZVI-3 <sup>(3)</sup>	X			TOC only
	NZVI-4 <sup>(3)</sup>	X			TOC only
<b>Round 5 - February 27, 2007</b>	PZ-6B-U	X	X		X
	PZ-6B-M	X	X		X
	PZ-6B-L	X	X		X
	NZVI-1 <sup>(3)</sup>	X	X		X
	NZVI-2 <sup>(3)</sup>	X	X		X
	NZVI-3 <sup>(3)</sup>	X	X		X
<b>Round 6 - May 2, 2007</b>	NZVI-4 <sup>(3)</sup>	X	X		X
	PZ-6B-U	X			X
	NZVI-1 <sup>(3)</sup>	X			X
	NZVI-2 <sup>(3)</sup>	X			X
	NZVI-3 <sup>(3)</sup>	X			X

**Notes**

(1) VOC analysis will include chlorobenzene and dichlorobenzenes.

(2) Parameters included in NAPs analysis are:

Field Parameters - Dissolved Oxygen, Redox, Specific Conductance, pH, Temperature, Turbidity

Laboratory NAPs - Total Organic Carbon, Chloride, Alkalinity as CaCO<sub>3</sub>, Sulfate (2 ppm detection level),

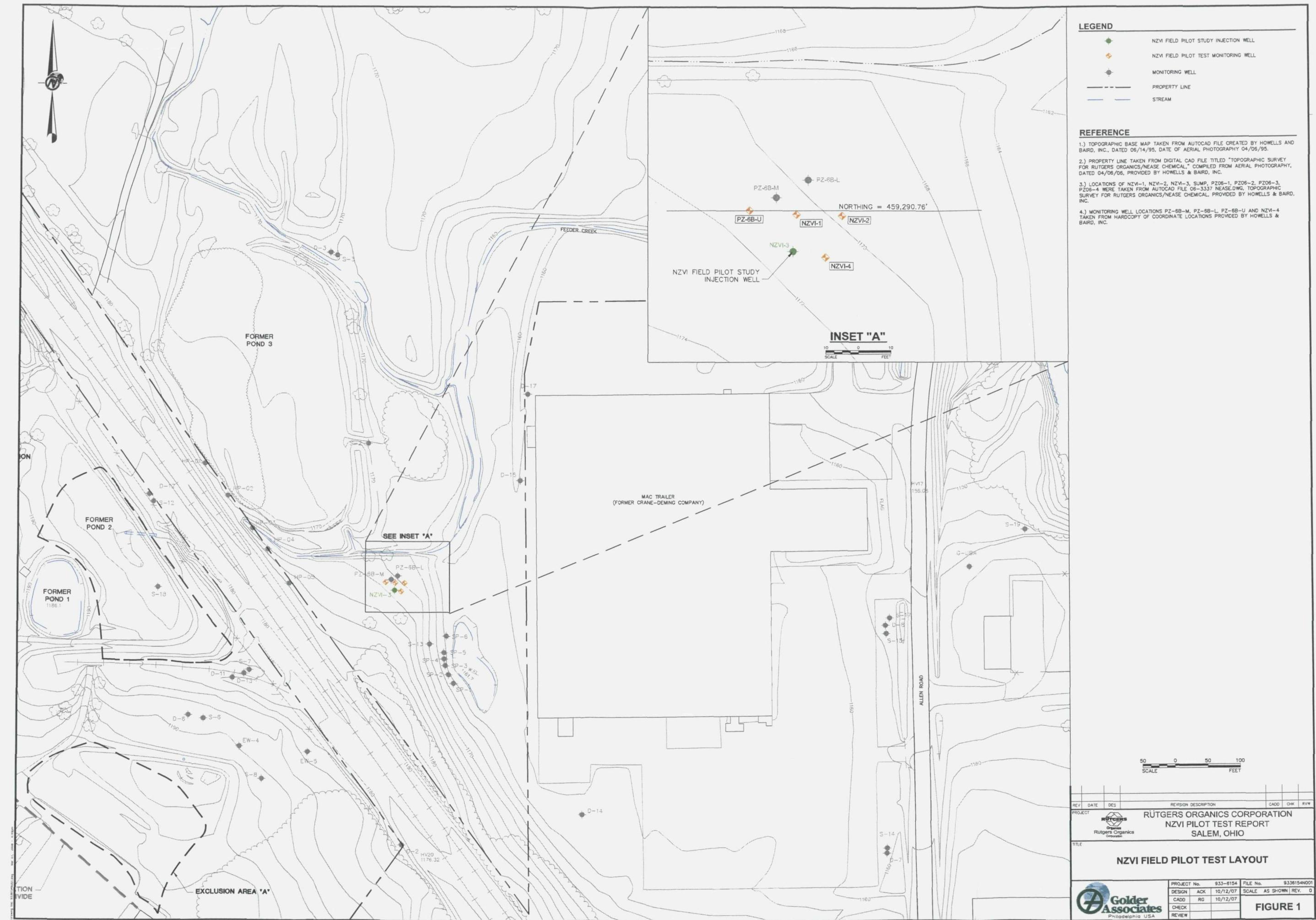
Total Sulfide (20 ppb detection level), Nitrate, Nitrite, Total Phosphate, Total Suspended Solids

Methane (ppt detection level), Ethane (ppt detection level), Ethene (ppt detection level), acetylene, and Ferrous Iron

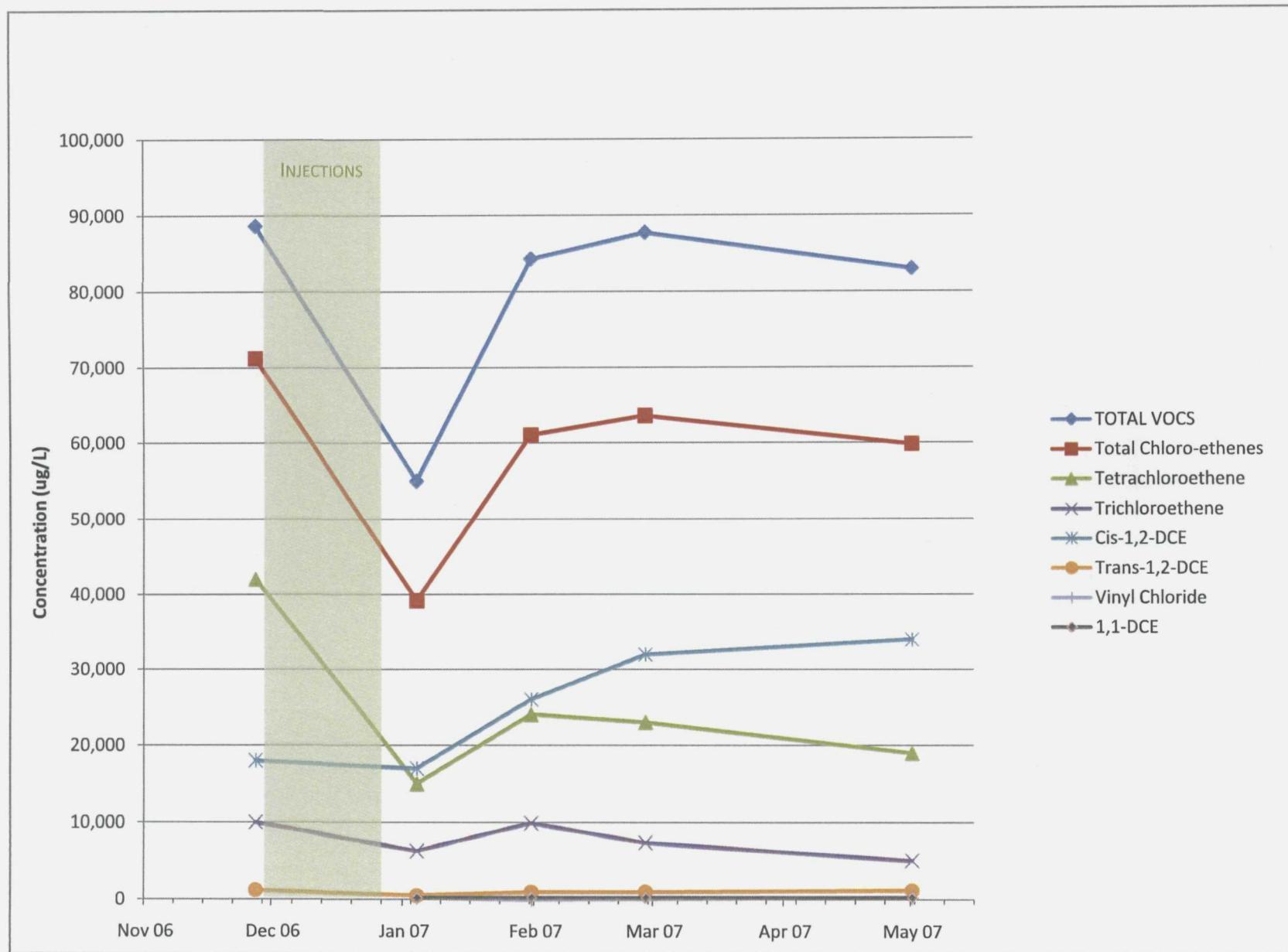
(3) NZVI field pilot study monitoring well.

(4) Mirex may be sampled at the end of the field pilot study depending upon the results of the baseline sampling program.

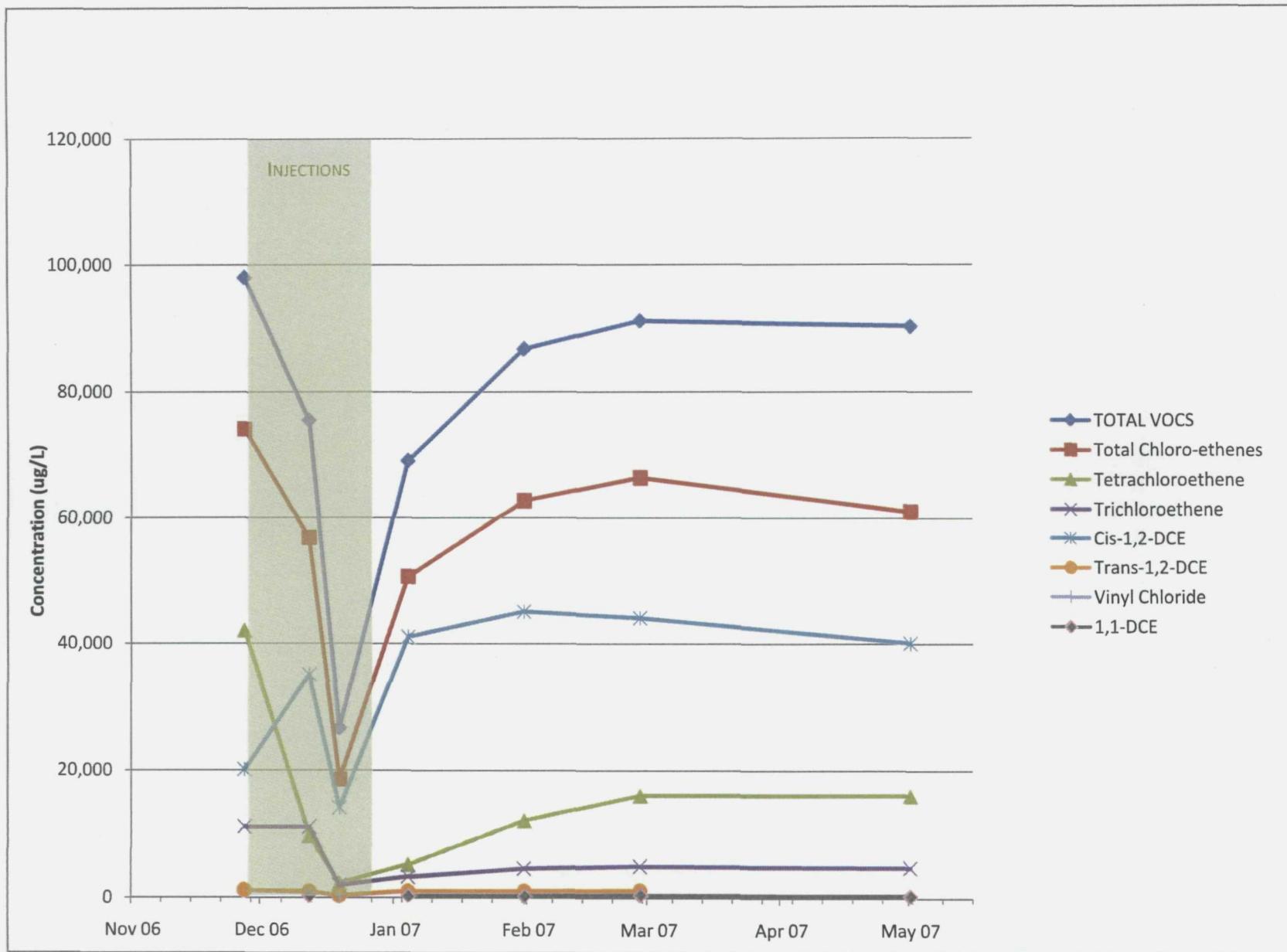
(5) NZVI injection commenced on November 28 and was completed on December 21, 2006.



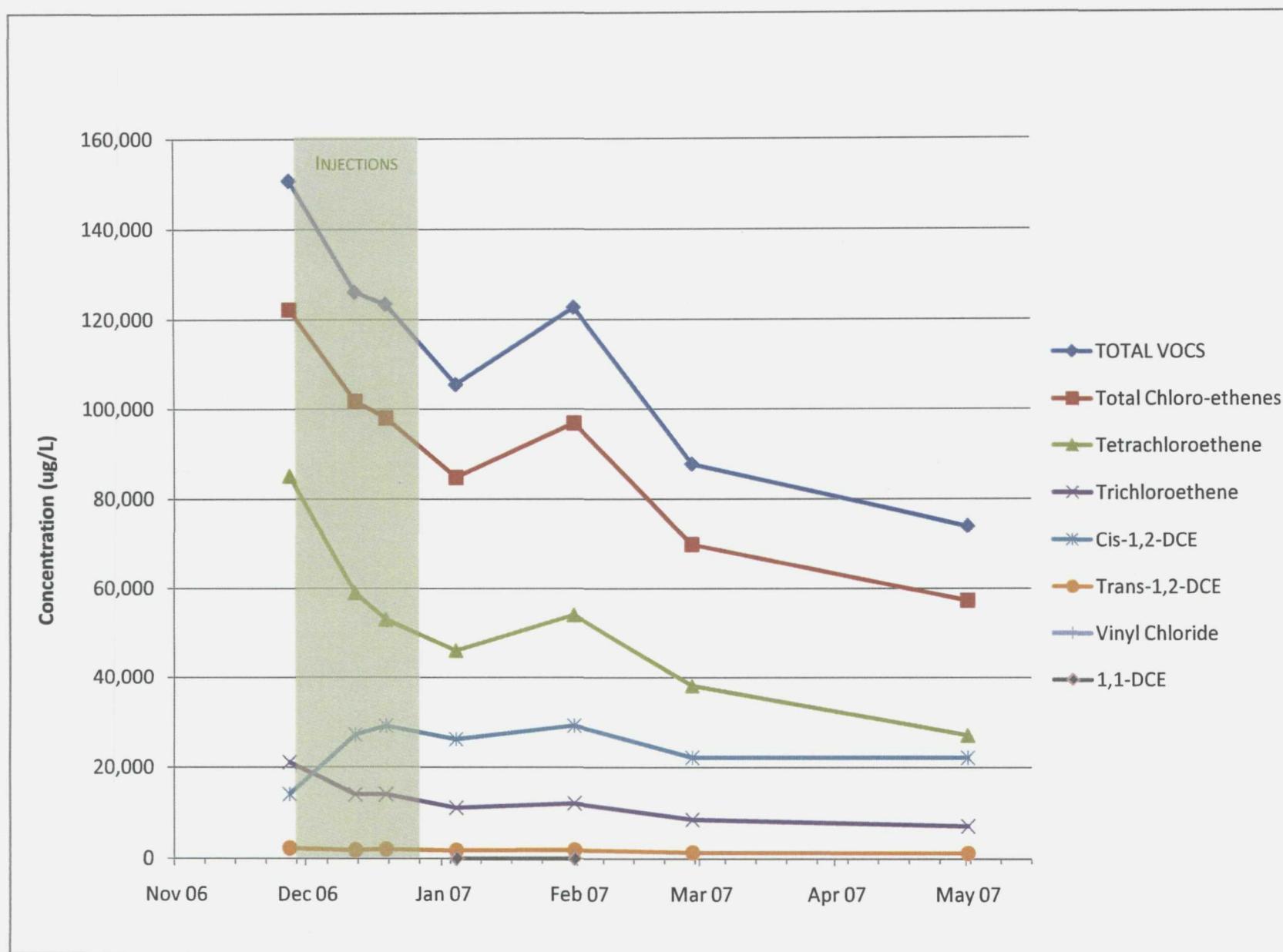
**Figure 2**  
**INJECTION WELL NZVI-3 - INDIVIDUAL VOCs**



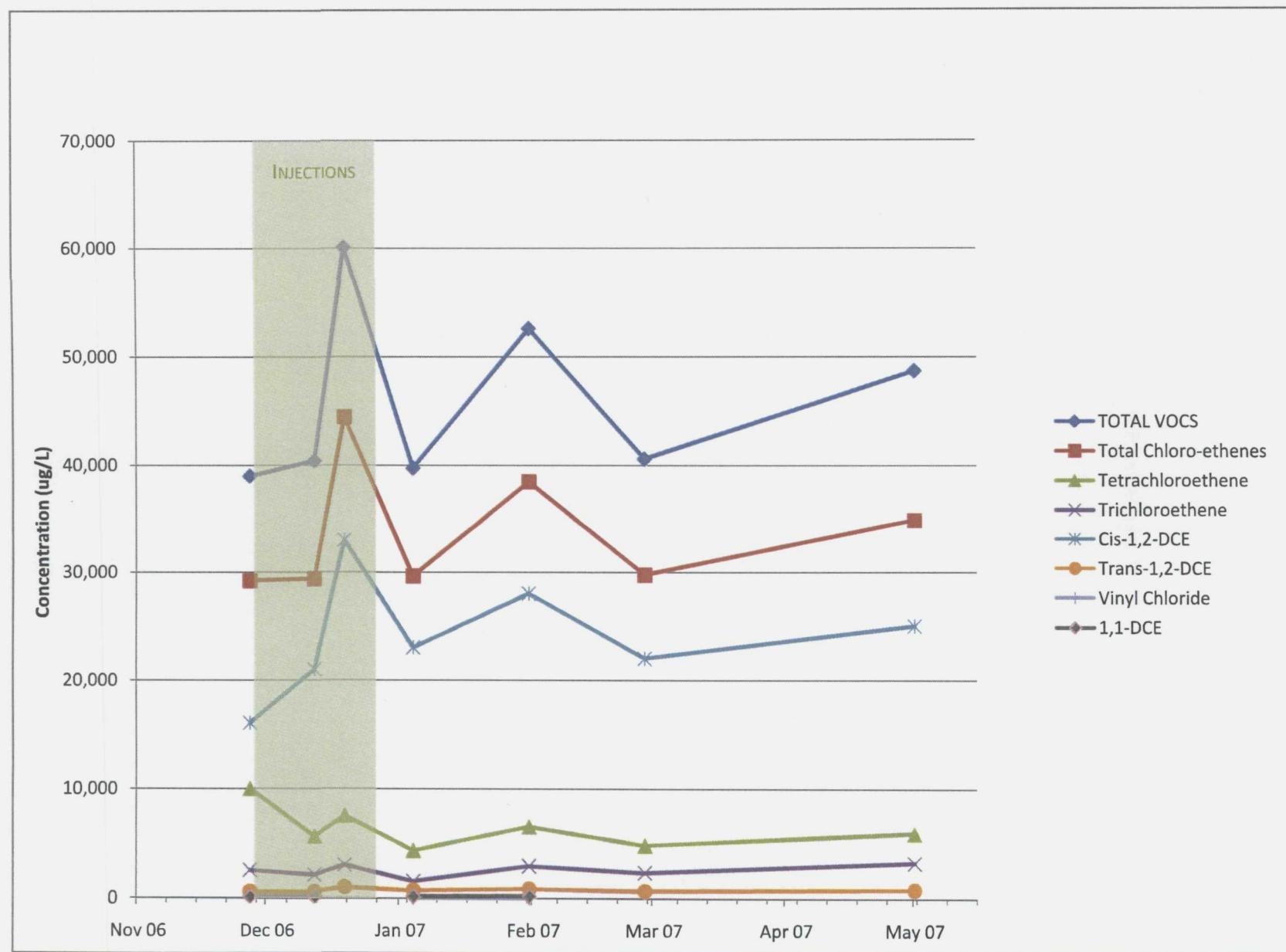
**Figure 3**  
**MONITORING WELL NZVI-4 - INDIVIDUAL VOCs**



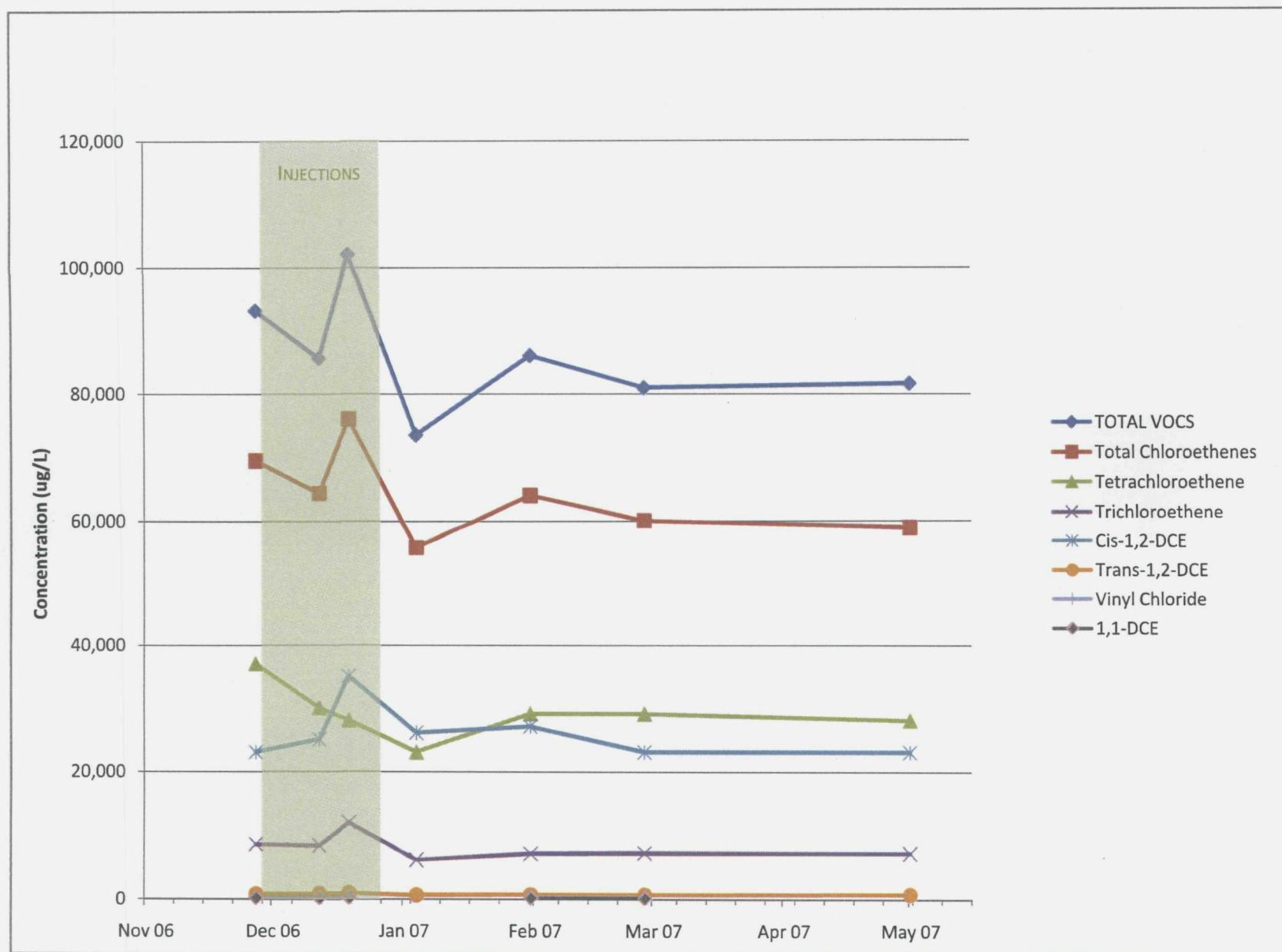
**Figure 4**  
**MONITORING WELL PZ-6B-U - INDIVIDUAL VOCs**



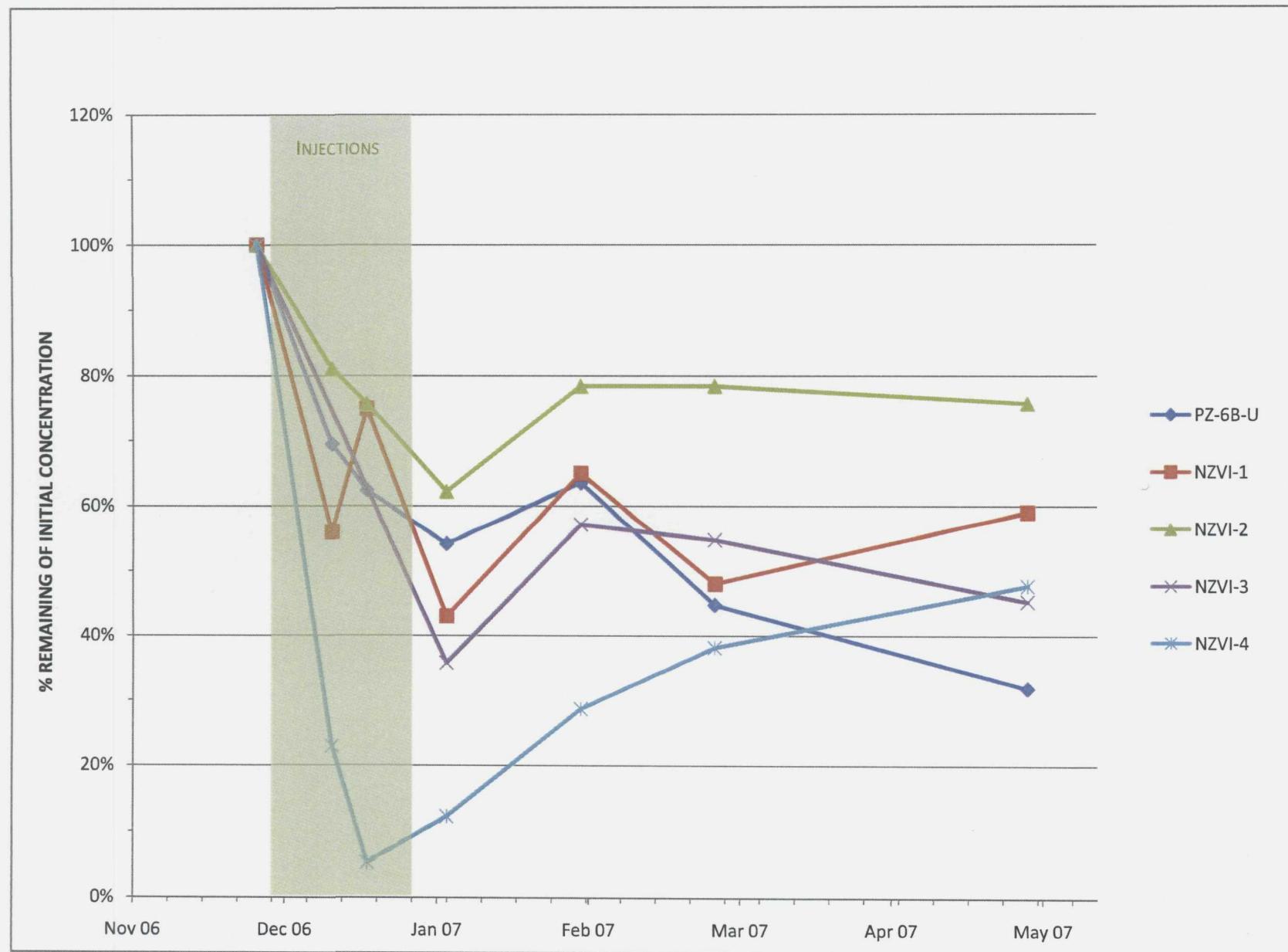
**Figure 5**  
**MONITORING WELL NZVI-1 - INDIVIDUAL VOCs**



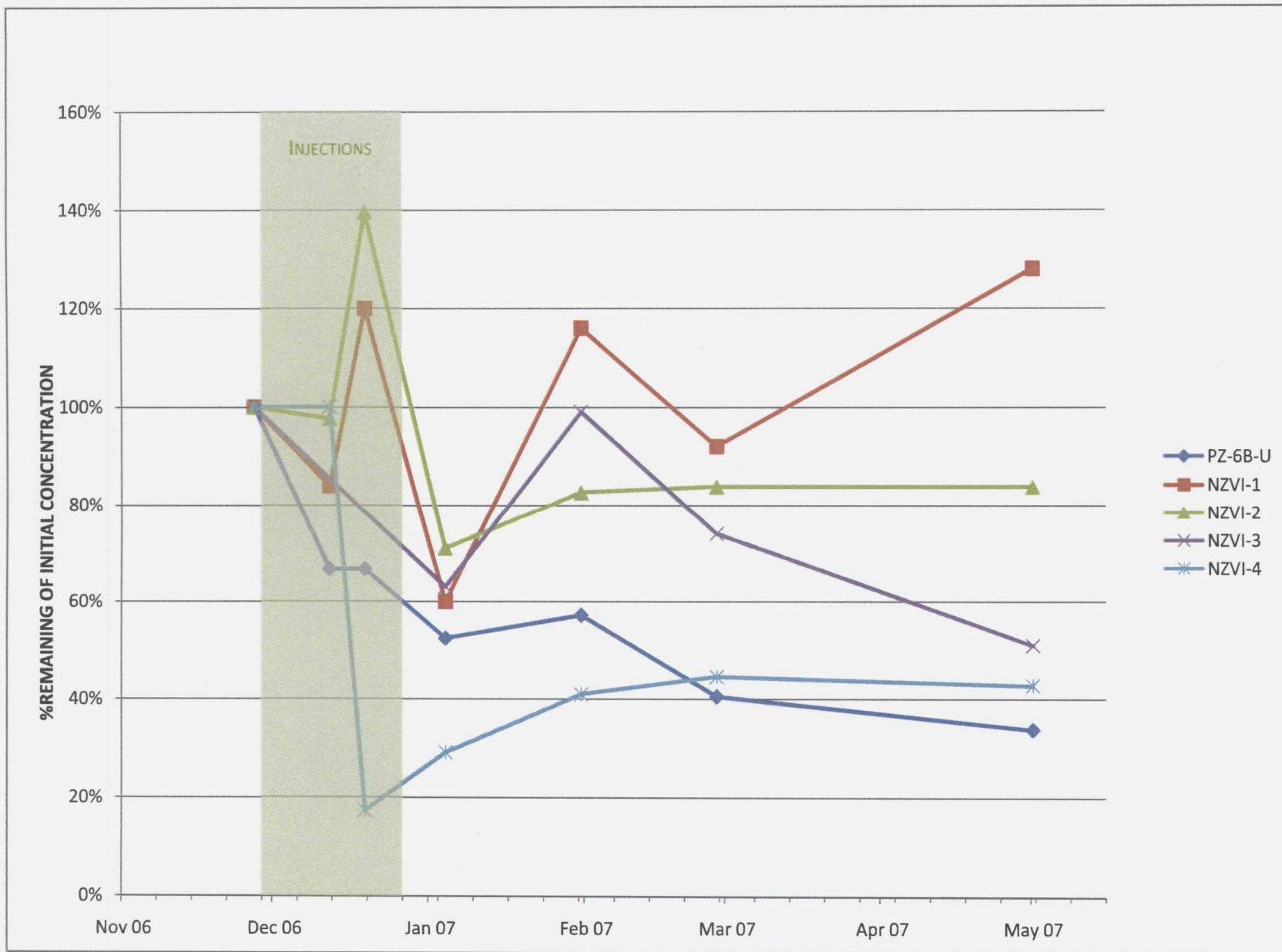
**Figure 6**  
**MONITORING WELL NZVI-2 - INDIVIDUAL VOCs**



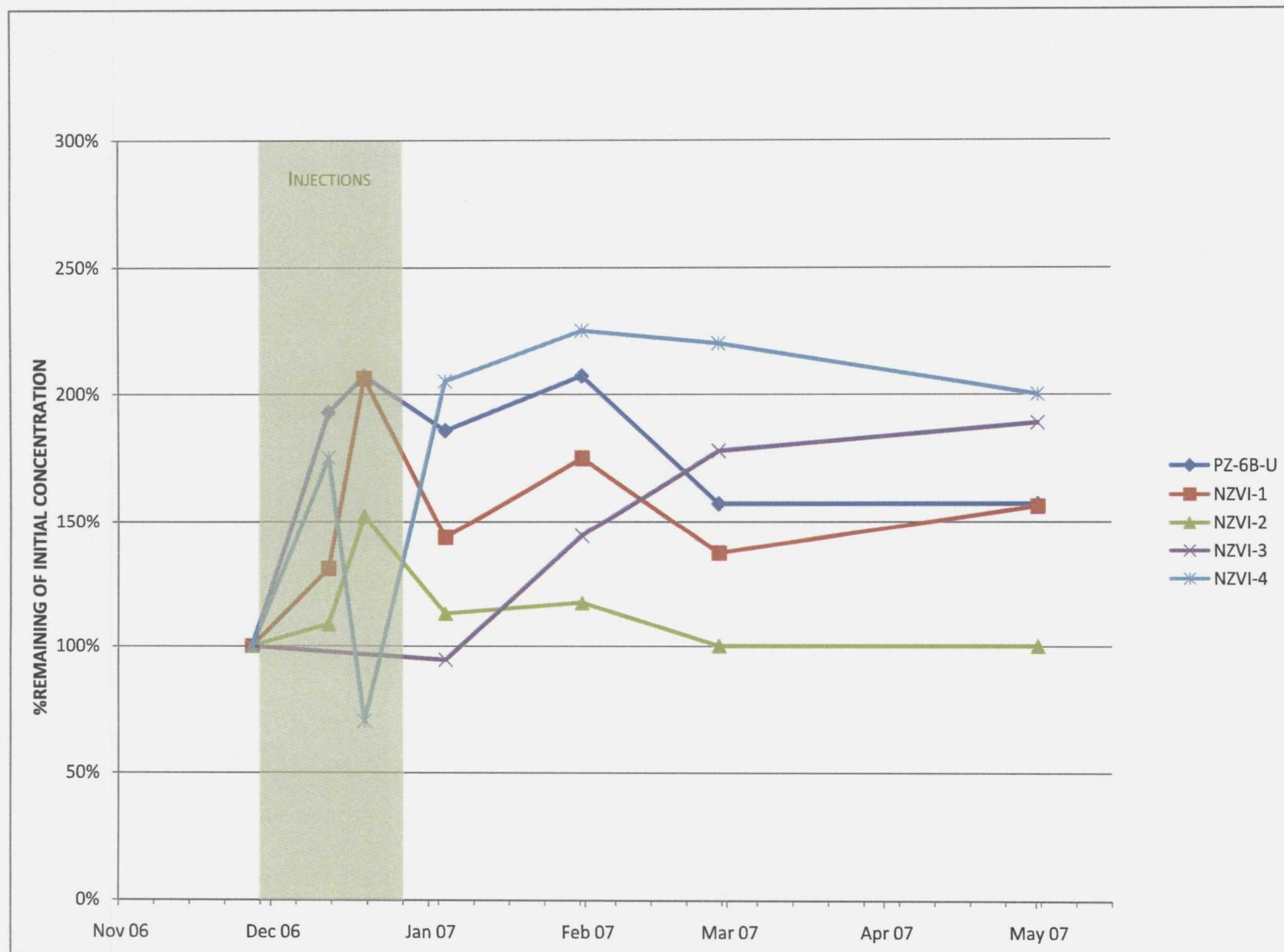
**Figure 7**  
**TETRACHLOROETHENE (PCE) CONCENTRATION CHANGES**



**Figure 8**  
**TRICHLOROETHENE (TCE) CONCENTRATION CHANGES**



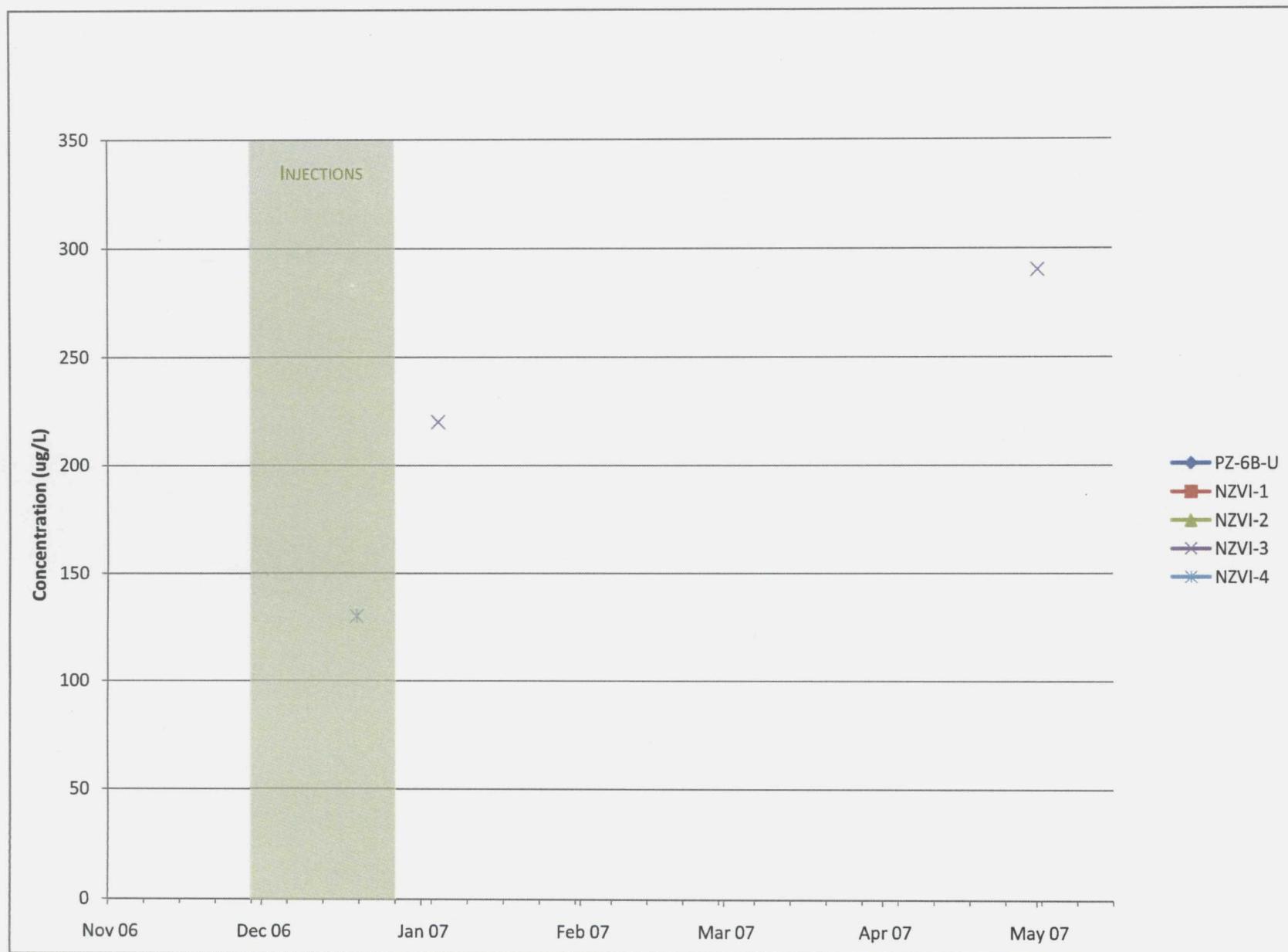
**Figure 9**  
**CIS-1,2-DICHLOROETHENE (CIS-DCE) CONCENTRATION CHANGES**



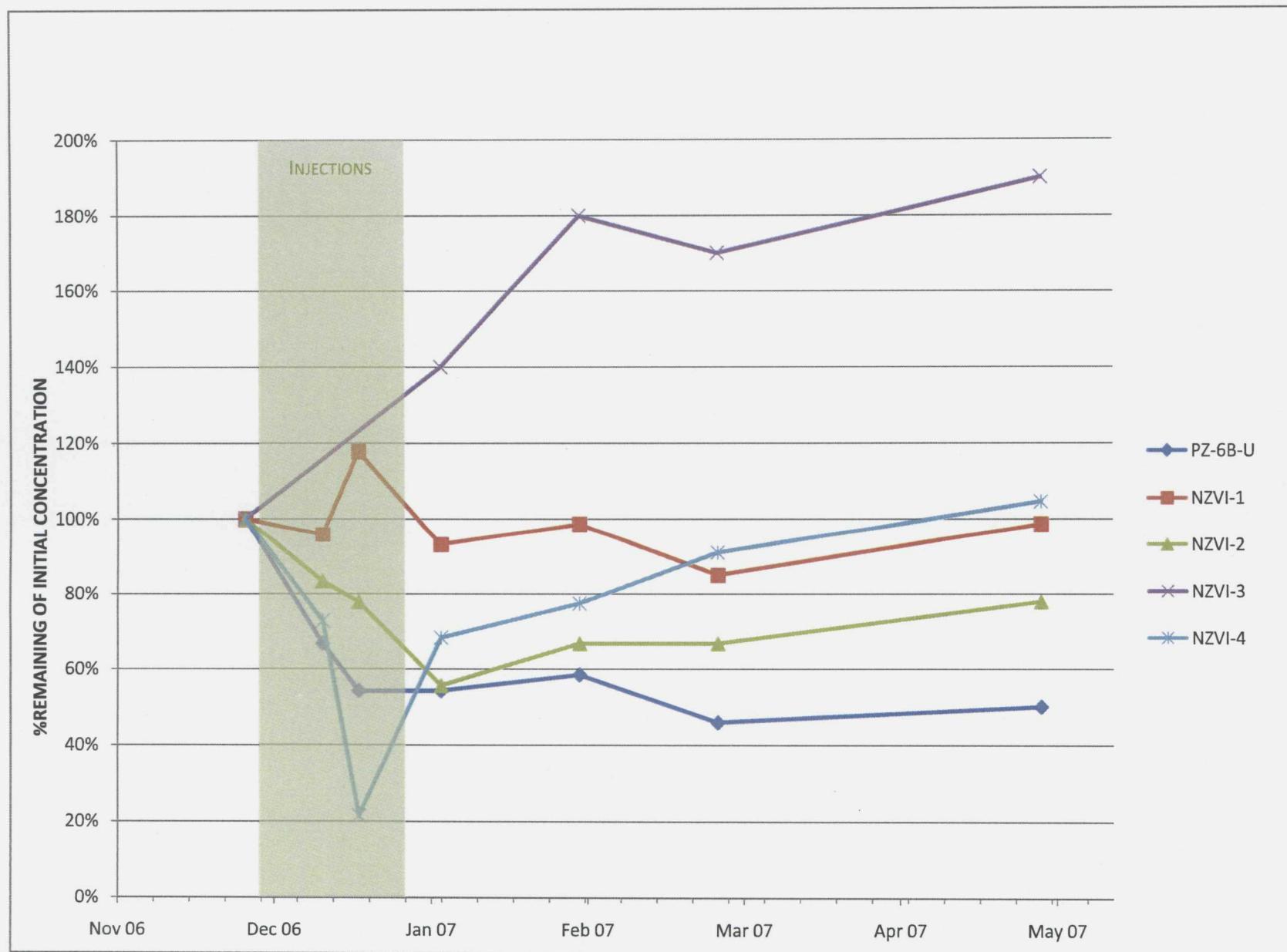
March 2008

**Figure 10**  
**VINYL CHLORIDE CONCENTRATIONS**

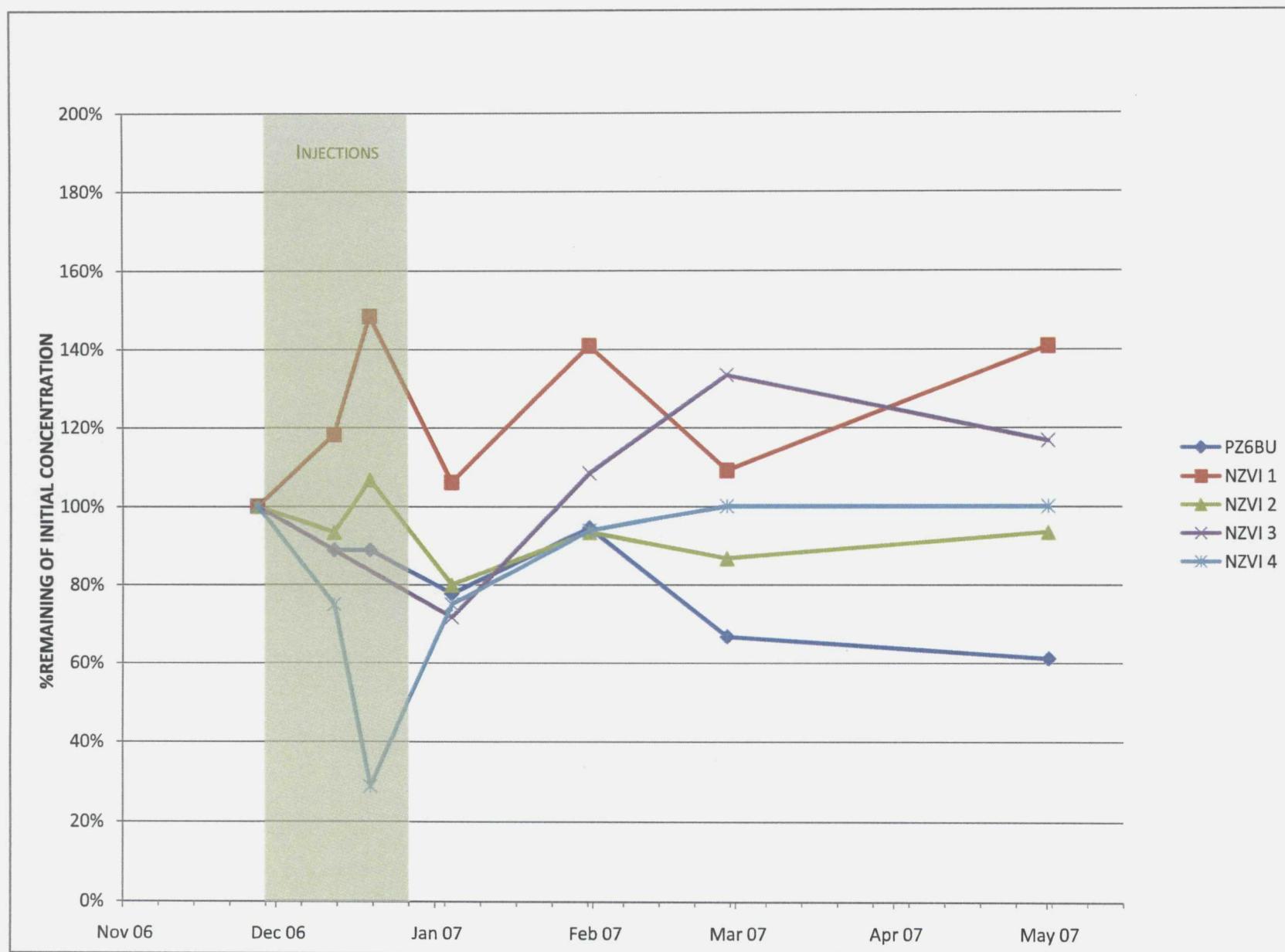
933-6154



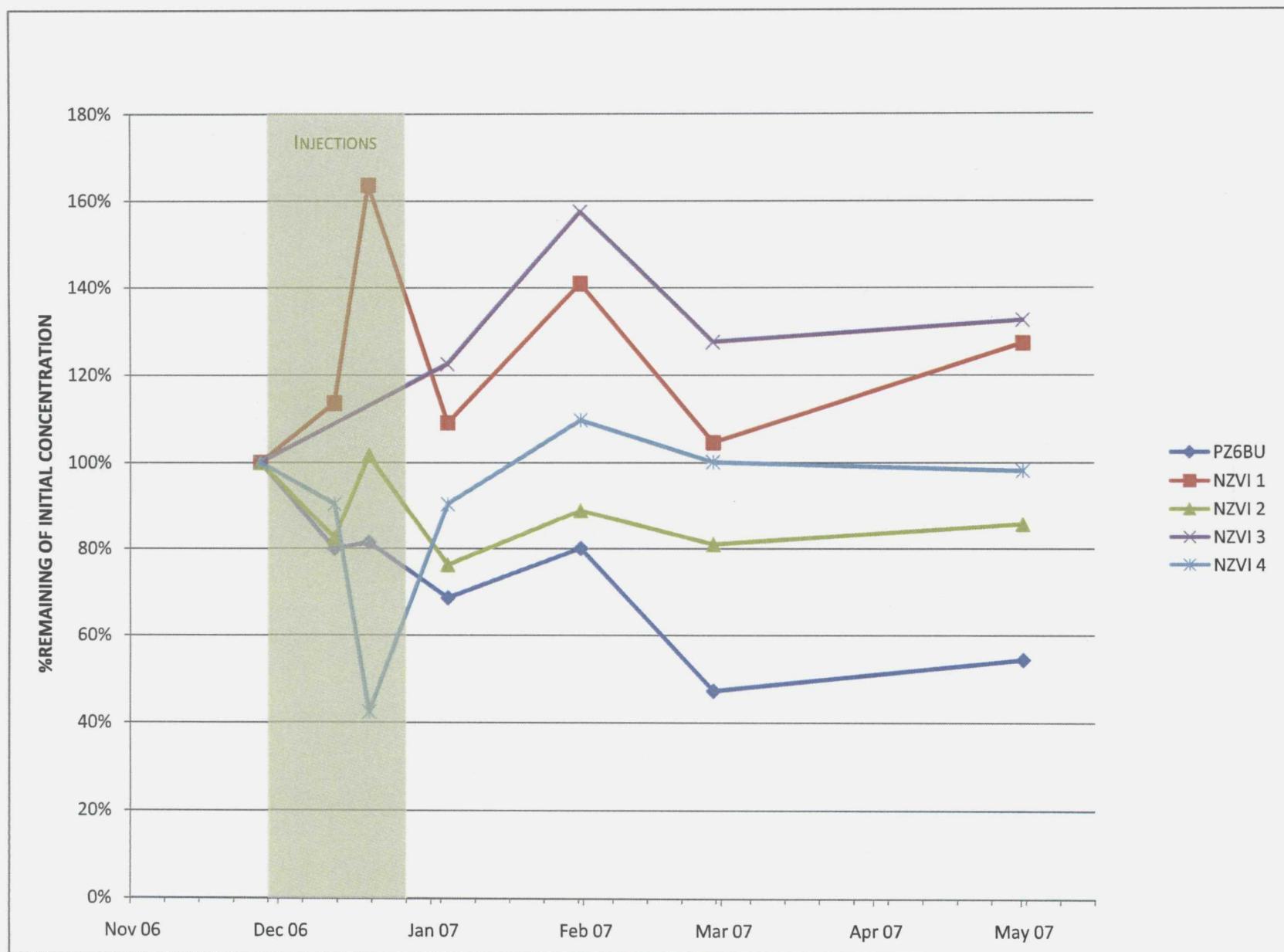
**Figure 11**  
**1,1,2,2-TETRACHLOROETHANE (1,1,2,2-TeCA) CONCENTRATION CHANGES**



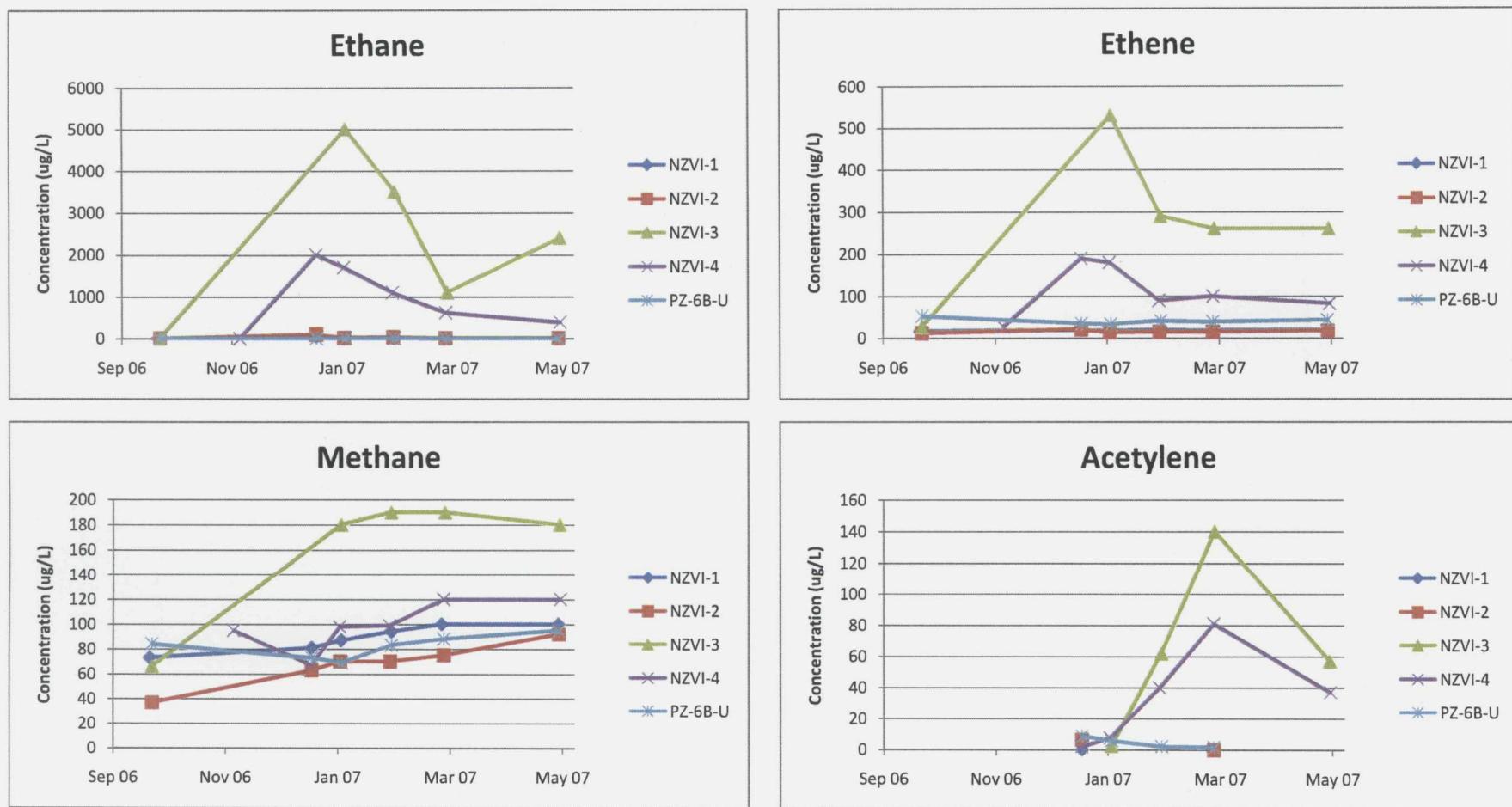
**Figure 12**  
**1,2-DICHLOROBENZENE CONCENTRATION CHANGES**



**Figure 13**  
**BENZENE CONCENTRATION CHANGES**

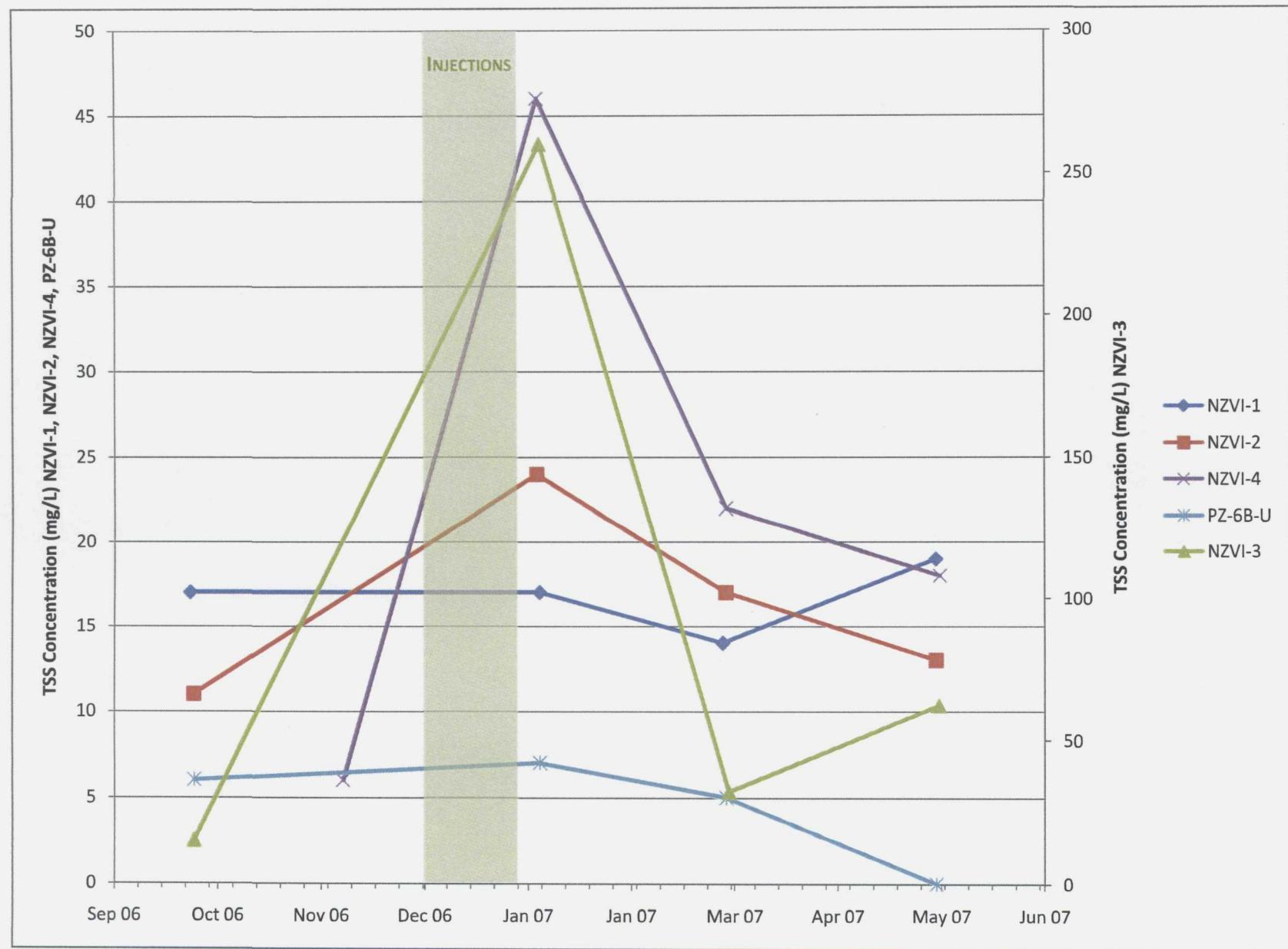


**Figure 14**  
**METHANE, ETHANE, ETHENE, AND ACETYLENE CONCENTRATIONS**

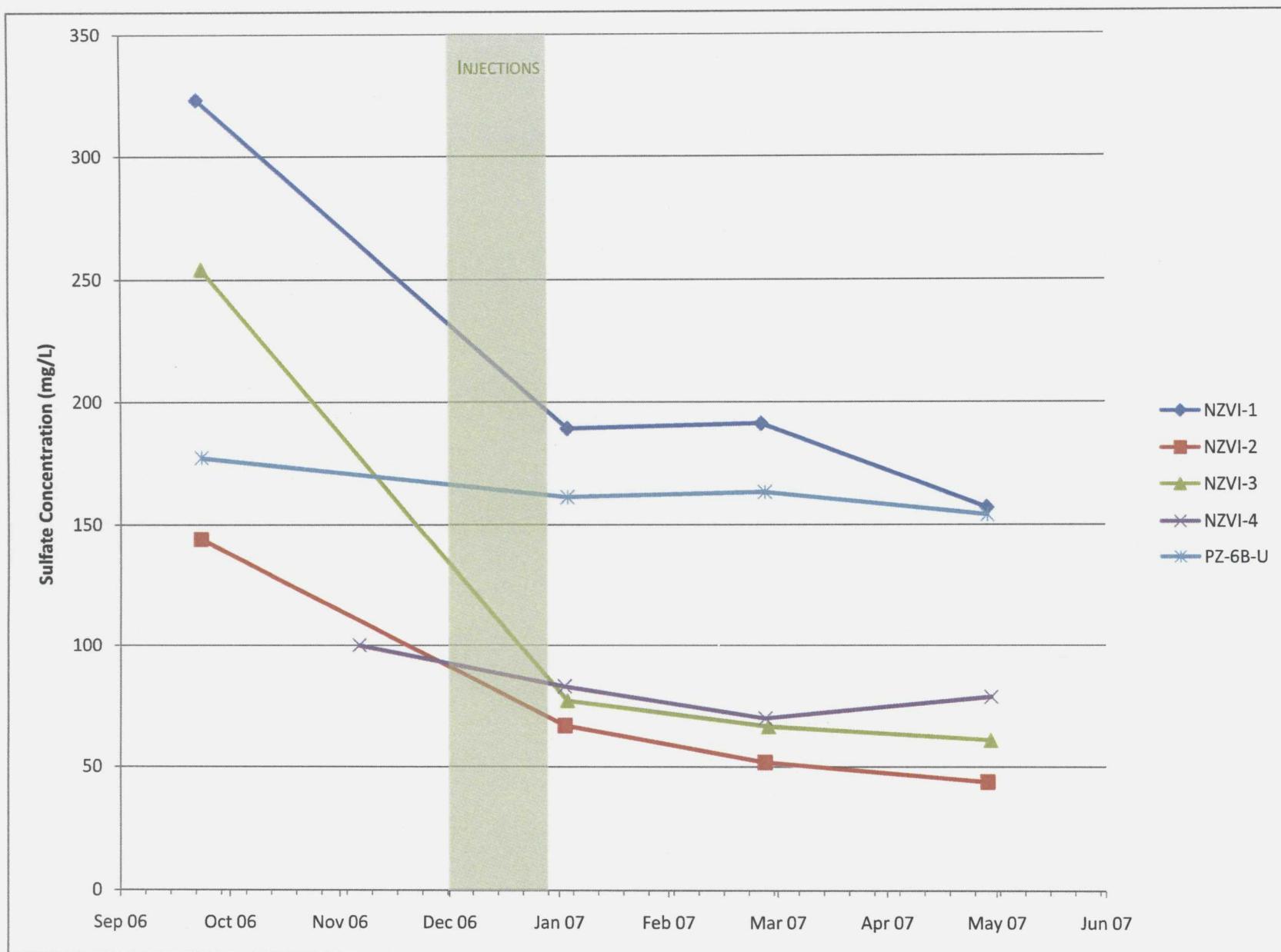


Injections: November 28 through December 21, 2006.

**Figure 15**  
**TOTAL SUSPENDED SOLIDS**



**Figure 16**  
**SULFATE CONCENTRATIONS**



**APPENDIX A**

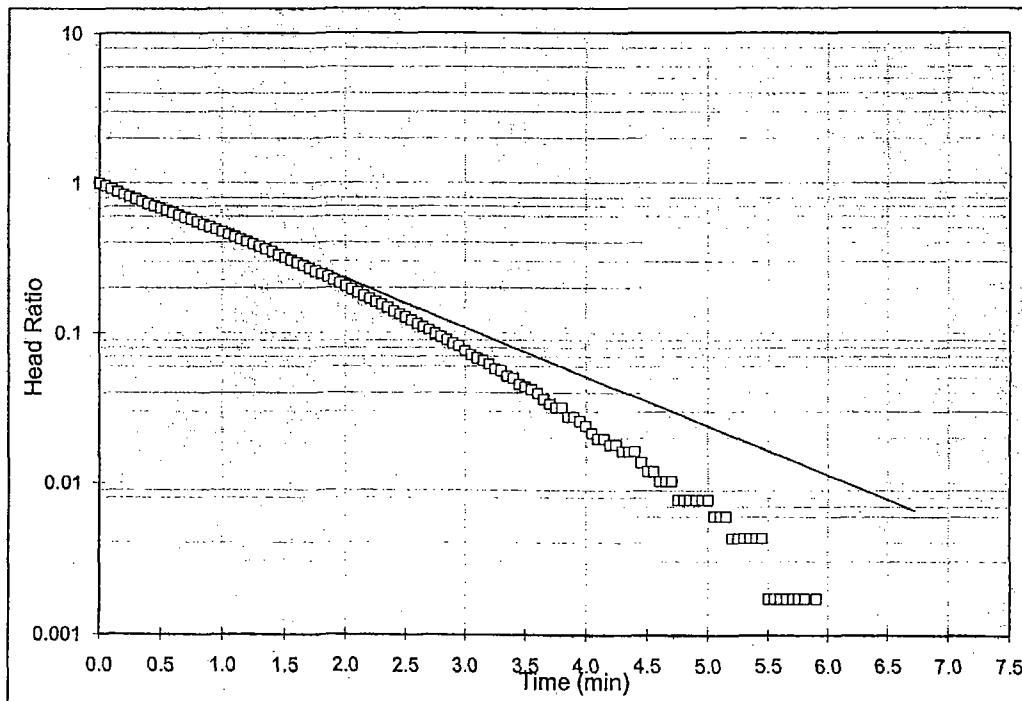
**SLUG TEST ANALYSIS**

**HVORSLEV SLUG TEST ANALYSIS  
FALLING HEAD TEST NZVI-1**

$$K = \frac{r_c^2}{2L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h_t$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS	
$r_c$ =	0.08	$K =$	3.29E-04 cm/sec
$R_e$ =	0.25	$K =$	9.34E-01 ft/day
$L_e$ =	17.0		
$t_1$ =	0.02		
$t_2$ =	6.72		
$h_{1(t1)}$ =	1.02		
$h_{2(t2)}$ =	0.007		



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 09/15/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
FALLING HEAD TEST NZVI-1**

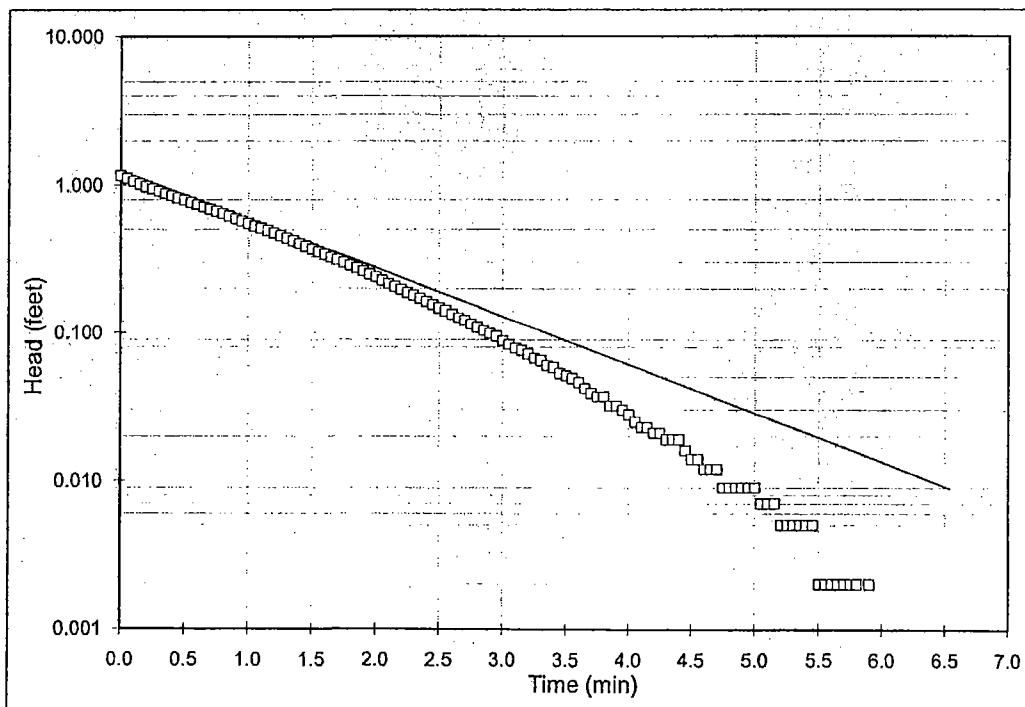
$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{l}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);  
 $R_e$  = effective radius (feet);  
 $L_e$  = length of screened interval (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)  
 $y_0$  = initial drawdown (feet)  
 $y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$r_w$ =	0.25	
$L_e$ =	17	
$\ln(R_e/r_w)$ =	3.02	$K = 2.36E-04 \text{ cm/sec}$
$y_0$ =	1.24	$K = 6.69E-01 \text{ ft/day}$
$y_t$ =	0.009	
$t$ =	6.5	



Project Name: NEASE / OH

Project No.: 933-6154

Test Date: 09/15/06

Analysis By: MJ

Checked By: FG

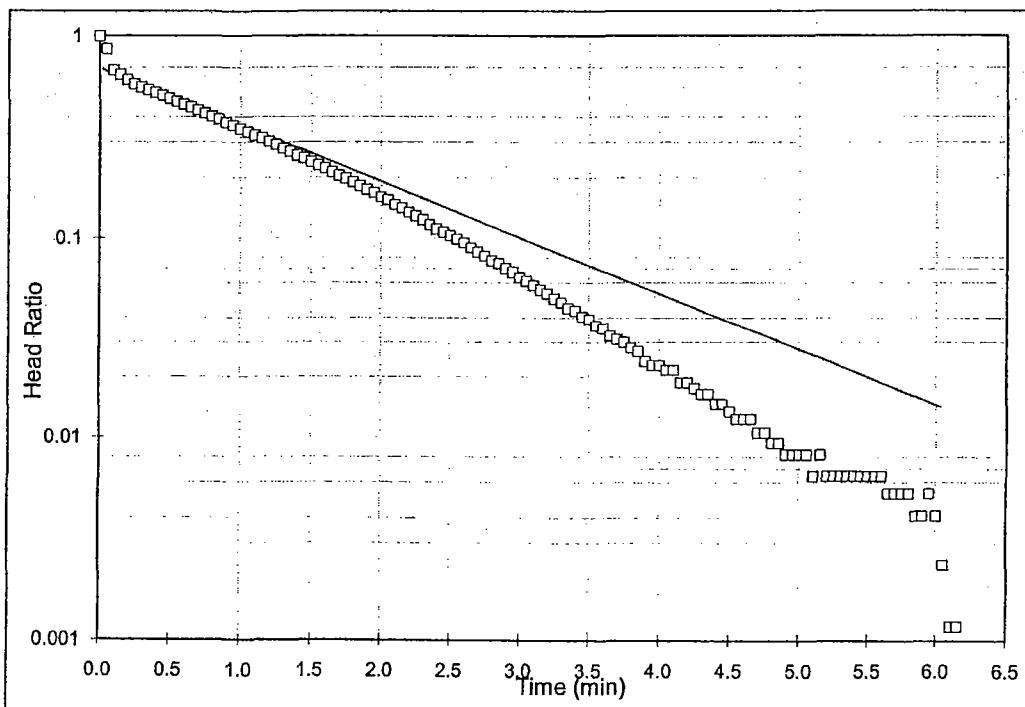
Analysis Date: 2/6/2008

**HVORSLEV SLUG TEST ANALYSIS  
RISING HEAD TEST NZVI-1**

$$K = \frac{r_c^2}{2L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h_t$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$R_e$ =	0.25	
$L_e$ =	17.0	
$t_1$ =	0.02	$K = 2.82E-04 \text{ cm/sec}$
$t_2$ =	6.03	$K = 8.00E-01 \text{ ft/day}$
$h_{1(t_1)}$ =	0.69	
$h_{2(t_2)}$ =	0.014	



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 09/15/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
RISING HEAD TEST NZVI-1**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{l}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)

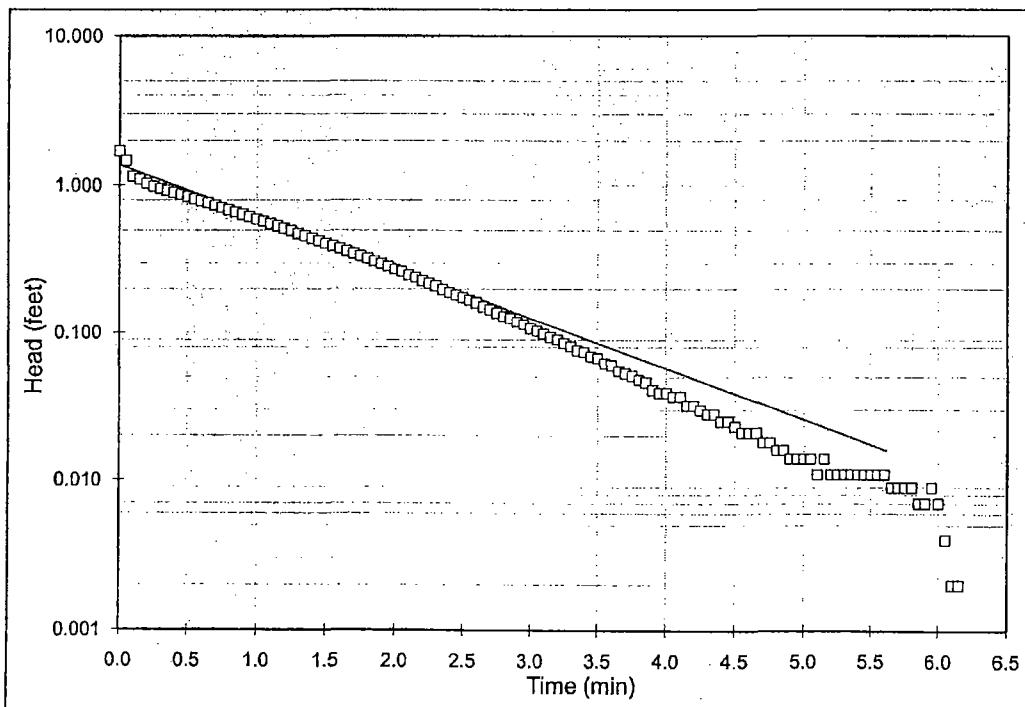
$R_e$  = effective radius (feet);

$y_0$  = initial drawdown (feet)

$L_e$  = length of screened interval (feet);

$y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS		RESULTS	
$r_c$ =	0.08		
$r_w$ =	0.25		
$L_e$ =	17		
$\ln(R_e/r_w)$ =	3.02	$K =$	2.48E-04 cm/sec
$y_0$ =	1.36	$K =$	7.04E-01 ft/day
$y_t$ =	0.016		
$t$ =	5.6		



Project Name: NEASE / OH

Analysis By: MJ

Project No.: 933-6154

Checked By: FG

Test Date: 09/15/06

Analysis Date: 2/6/2008

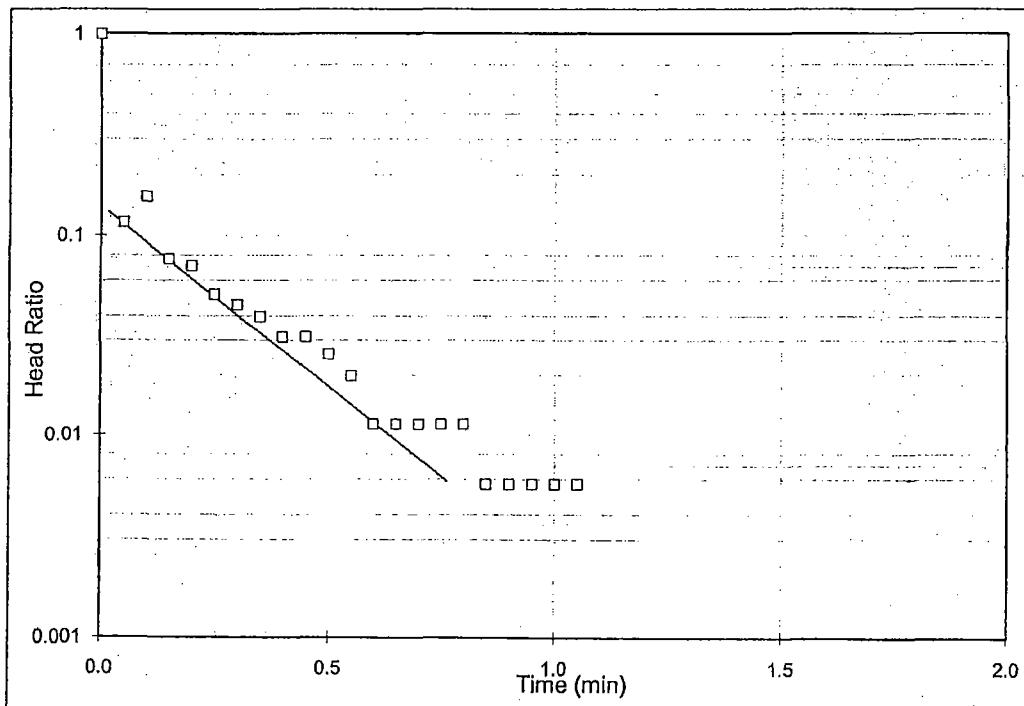
Figure A-5

**HVORSLEV SLUG TEST ANALYSIS  
FALLING HEAD TEST NZVI-2**

$$K = \frac{r_c^2}{2L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h_t$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS	
$r_c$ =	0.08	$K=$	1.82E-03 cm/sec
$R_e$ =	0.25	$K=$	5.16E+00 ft/day
$L_e$ =	17.0		
$t_1$ =	0.02		
$t_2$ =	0.76		
$h_{1(t1)}$ =	0.13		
$h_{2(t2)}$ =	0.006		



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 09/15/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
FALLING HEAD TEST NZVI-2**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{1}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)

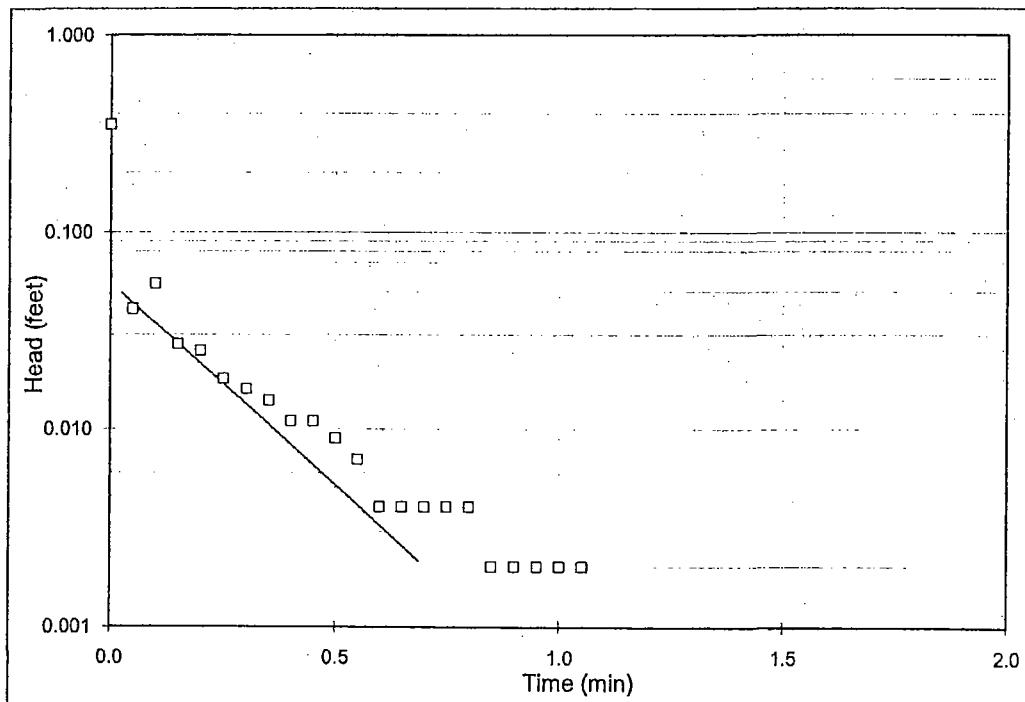
$R_e$  = effective radius (feet);

$y_0$  = initial drawdown (feet)

$L_e$  = length of screened interval (feet);

$y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$r_w$ =	0.25	
$L_e$ =	17	
$\ln(R_e/r_w)$ =	3.02	$K = 1.45E-03 \text{ cm/sec}$
$y_0$ =	0.05	$K = 4.10E+00 \text{ ft/day}$
$y_t$ =	0.002	
$t$ =	0.7	



Project Name: NEASE / OH

Analysis By: MJ

Project No.: 933-6154

Checked By: FG

Test Date: 09/15/06

Analysis Date: 2/6/2008

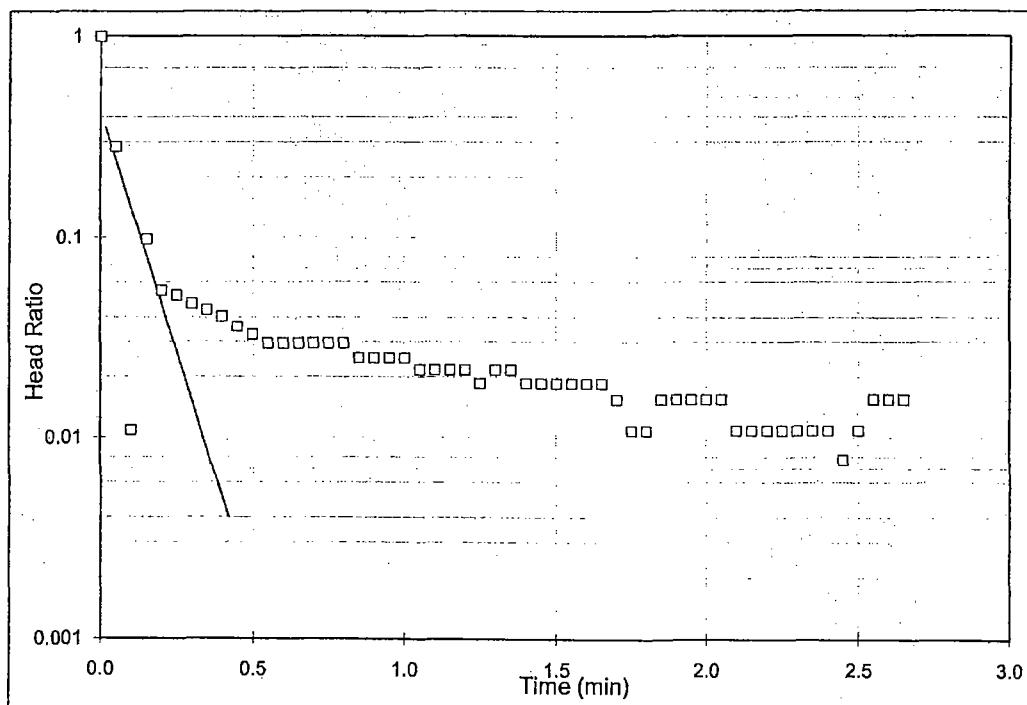
Figure A-7

**HVORSLEV SLUG TEST ANALYSIS  
RISING HEAD TEST NZVI-2**

$$K = \frac{r_c^2}{2L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h_t$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$R_e$ =	0.25	
$L_e$ =	17.0	$K = 4.87E-03 \text{ cm/sec}$
$t_1$ =	0.02	$K = 1.38E+01 \text{ ft/day}$
$t_2$ =	0.42	
$h_{1(t_1)}$ =	0.35	
$h_{2(t_2)}$ =	0.004	



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 09/15/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
RISING HEAD TEST NZVI-2**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{I}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)

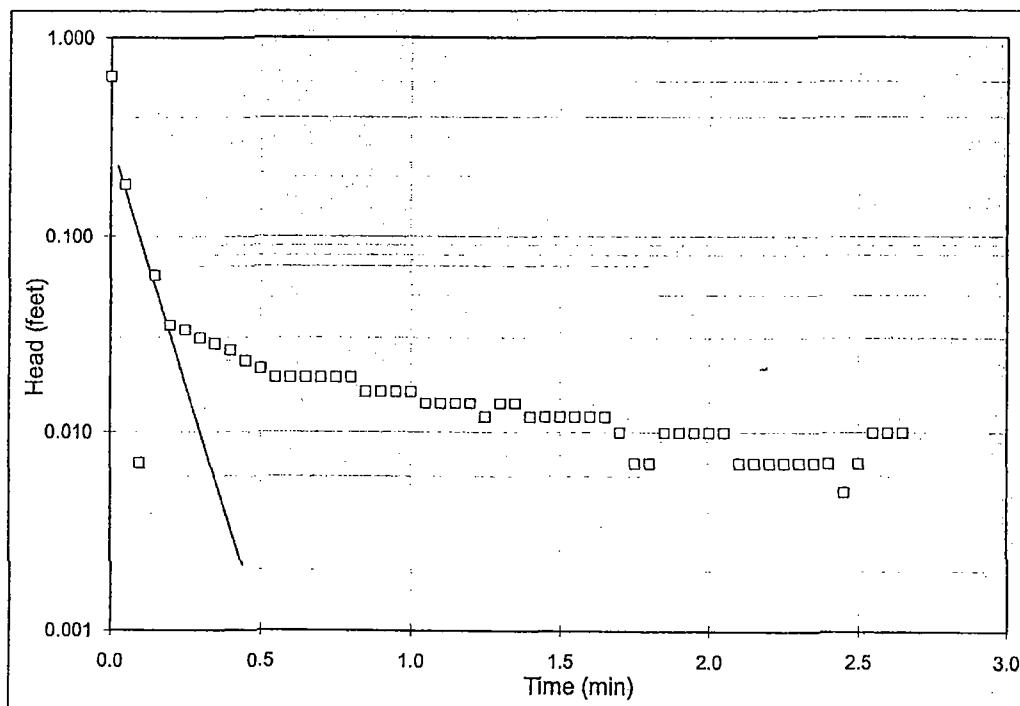
$R_e$  = effective radius (feet);

$y_0$  = initial drawdown (feet)

$L_e$  = length of screened interval (feet);

$y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$r_w$ =	0.25	
$L_e$ =	17	
$\ln(R_e/r_w)$ =	3.02	$K = 3.38E-03 \text{ cm/sec}$
$y_0$ =	0.24	$K = 9.57E+00 \text{ ft/day}$
$y_t$ =	0.002	
$t$ =	0.4	



Project Name: NEASE / OH

Analysis By: MJ

Project No.: 933-6154

Checked By: FG

Test Date: 09/15/06

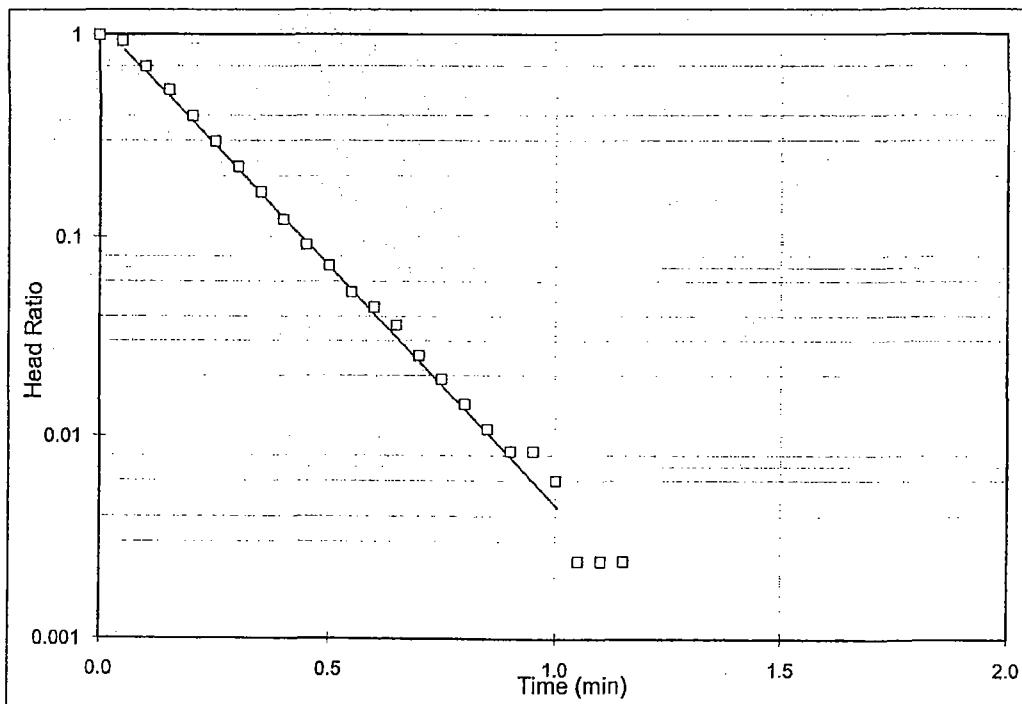
Analysis Date: 2/6/2008

**HYDROSLEV SLUG TEST ANALYSIS  
FALLING HEAD TEST NZVI-3**

$$K = \frac{r_c^2}{2L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h_t$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$R_e$ =	0.25	
$L_e$ =	17.3	
$t_1$ =	0.06	$K = 2.39E-03 \text{ cm/sec}$
$t_2$ =	1.00	$K = 6.77E+00 \text{ ft/day}$
$h_{1(t1)}$ =	0.84	
$h_{2(t2)}$ =	0.004	



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 09/15/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
FALLING HEAD TEST NZVI-3**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{I}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)

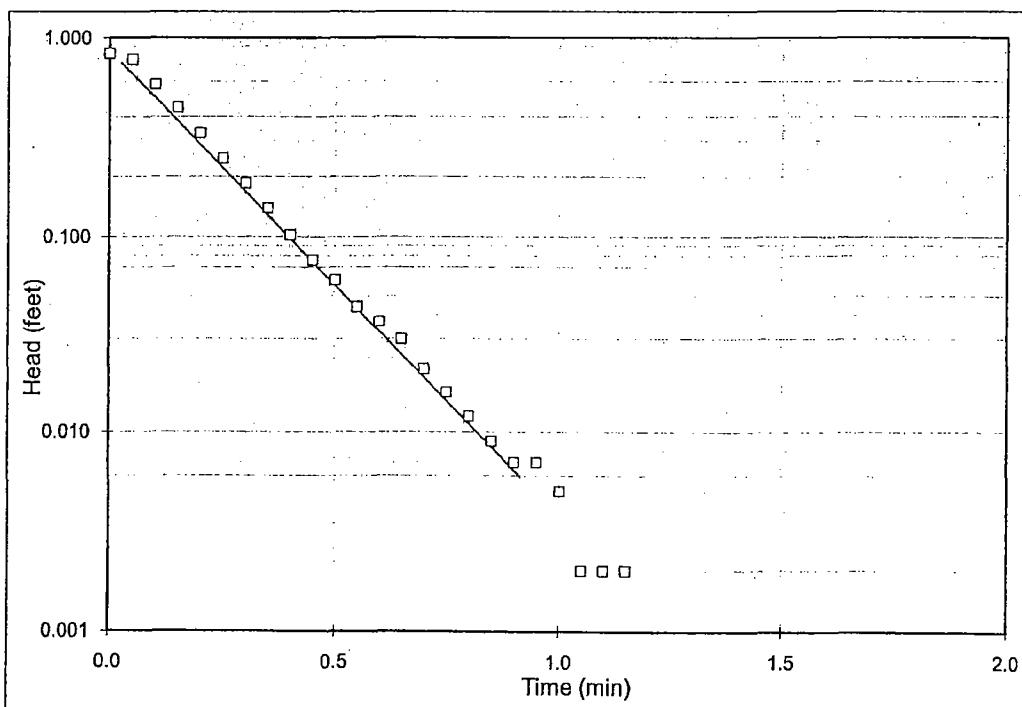
$R_e$  = effective radius (feet);

$y_0$  = initial drawdown (feet)

$L_e$  = length of screened interval (feet);

$y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$r_w$ =	0.25	
$L_e$ =	17.3	
$\ln(R_e/r_w)$ =	3.02	$K = 1.64E-03 \text{ cm/sec}$
$y_0$ =	0.77	$K = 4.64E+00 \text{ ft/day}$
$y_t$ =	0.006	
$t$ =	0.9	



Project Name: NEASE / OH  
Project No.: 933-6154  
Test Date: 09/15/06

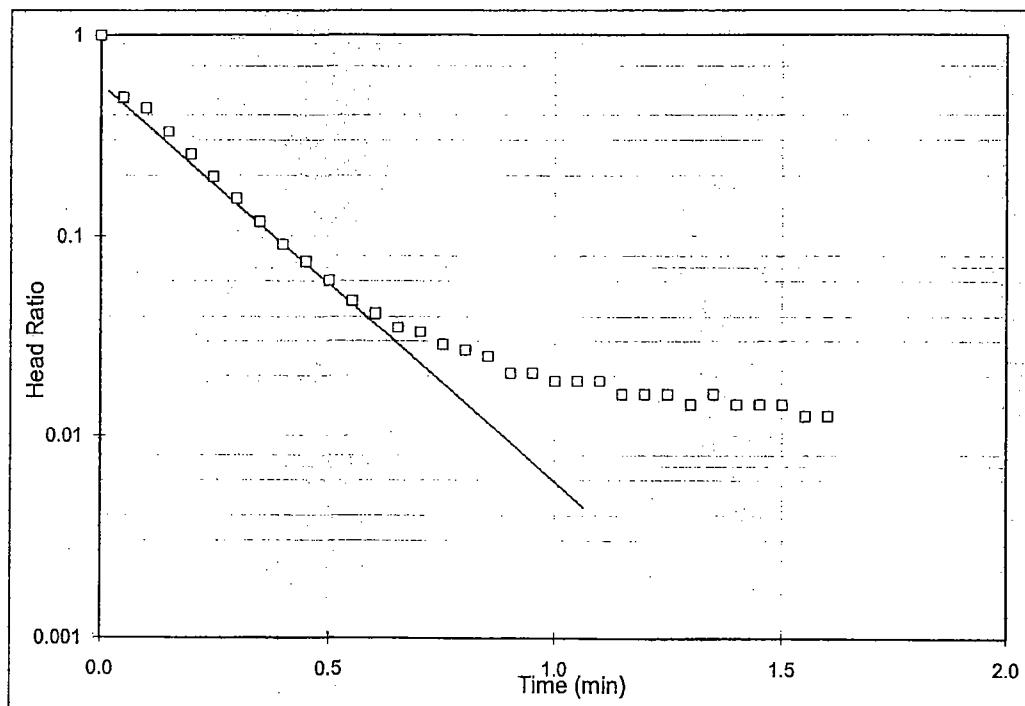
Analysis By: MJ  
Checked By: FG  
Analysis Date: 2/6/2008

**HVORSLEV SLUG TEST ANALYSIS  
RISING HEAD TEST NZVI-3**

$$K = \frac{r_c^2}{2L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln \left( \frac{h_1}{h_2} \right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h_t$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS	
$r_c$ =	0.08	$K =$	1.97E-03 cm/sec
$R_e$ =	0.25	$K =$	5.59E+00 ft/day
$L_e$ =	17.3		
$t_1$ =	0.02		
$t_2$ =	1.06		
$h_{1(t_1)}$ =	0.53		
$h_{2(t_2)}$ =	0.004		



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 09/15/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
RISING HEAD TEST NZVI-3**

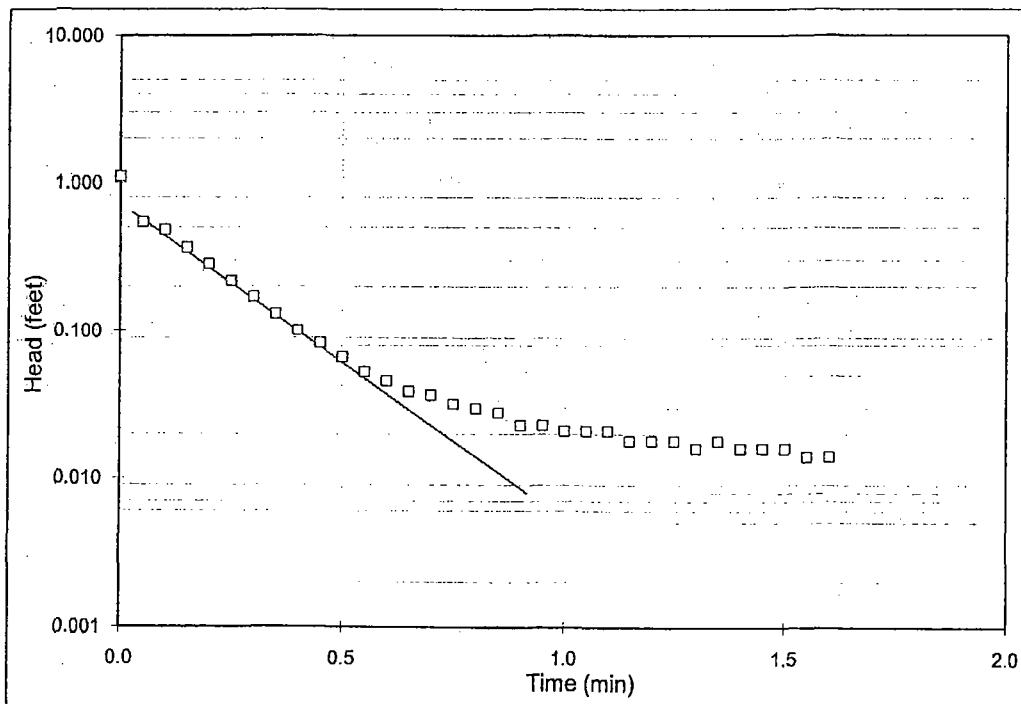
$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{I}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);  
 $R_e$  = effective radius (feet);  
 $L_e$  = length of screened interval (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)  
 $y_0$  = initial drawdown (feet)  
 $y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$r_w$ =	0.25	
$L_e$ =	17.3	
$\ln(R_e/r_w)$ =	3.02	$K = 1.48E-03 \text{ cm/sec}$
$y_0$ =	0.65	$K = 4.20E+00 \text{ ft/day}$
$y_t$ =	0.008	
$t$ =	0.9	



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 09/15/06

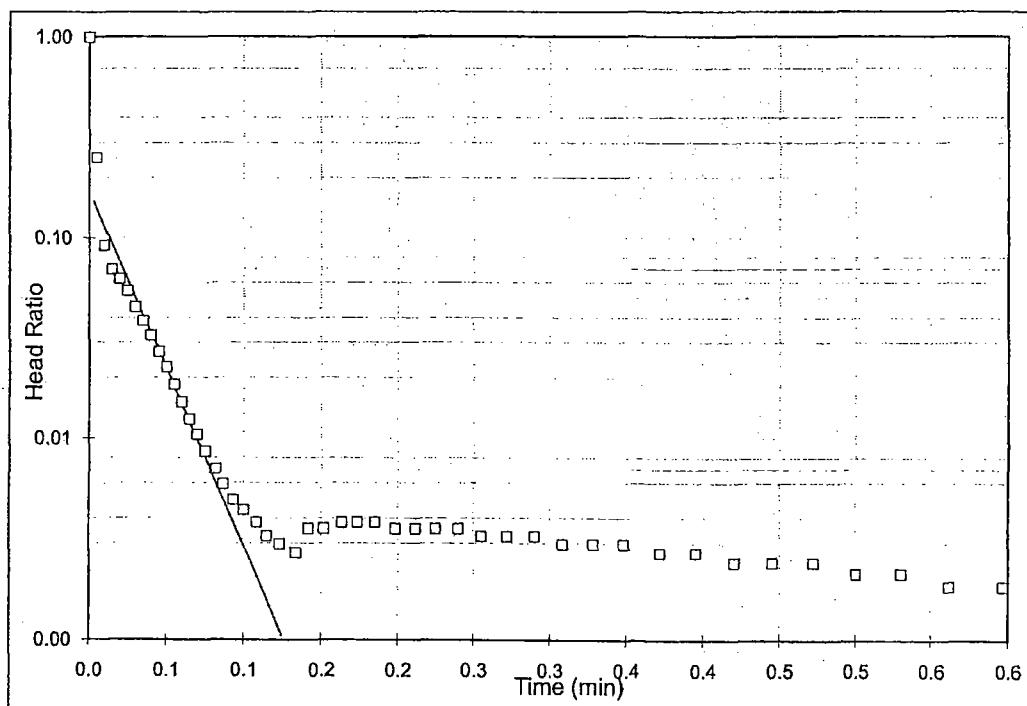
Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**HYDROSLEV SLUG TEST ANALYSIS  
FALLING HEAD TEST NZVI-4**

$$K = \frac{r_c^2}{2L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h_t$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$R_e$ =	0.25	
$L_e$ =	22.0	
$t_1$ =	0.00	$K = 1.47E-02 \text{ cm/sec}$
$t_2$ =	0.13	$K = 4.16E+01 \text{ ft/day}$
$h_{1(t1)}$ =	0.15	
$h_{2(t2)}$ =	0.001	



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 11/09/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
FALLING HEAD TEST NZVI-4**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{1}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)

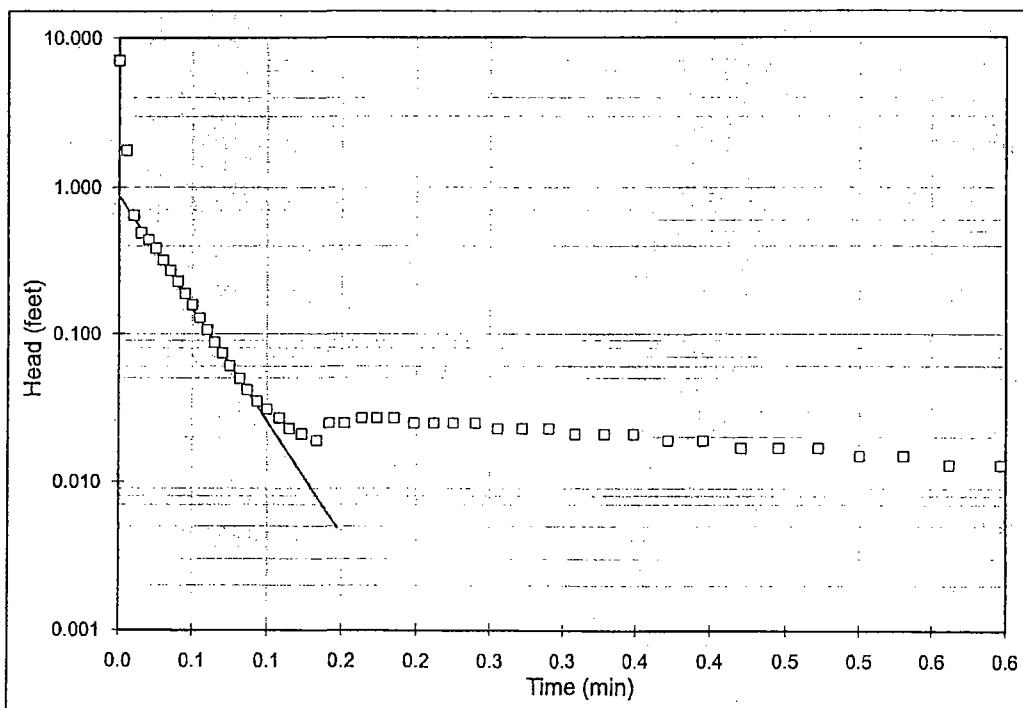
$R_e$  = effective radius (feet);

$y_0$  = initial drawdown (feet)

$L_e$  = length of screened interval (feet);

$y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$r_w$ =	0.25	
$L_e$ =	22	
$\ln(R_e/r_w)$ =	4.66	$K = 1.31E-02 \text{ cm/sec}$
$y_0$ =	0.86	$K = 3.72E+01 \text{ ft/day}$
$y_t$ =	0.005	
$t$ =	0.1	



Project Name: NEASE / OH

Analysis By: MJ

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Checked By: FG

Test Date: 11/09/06

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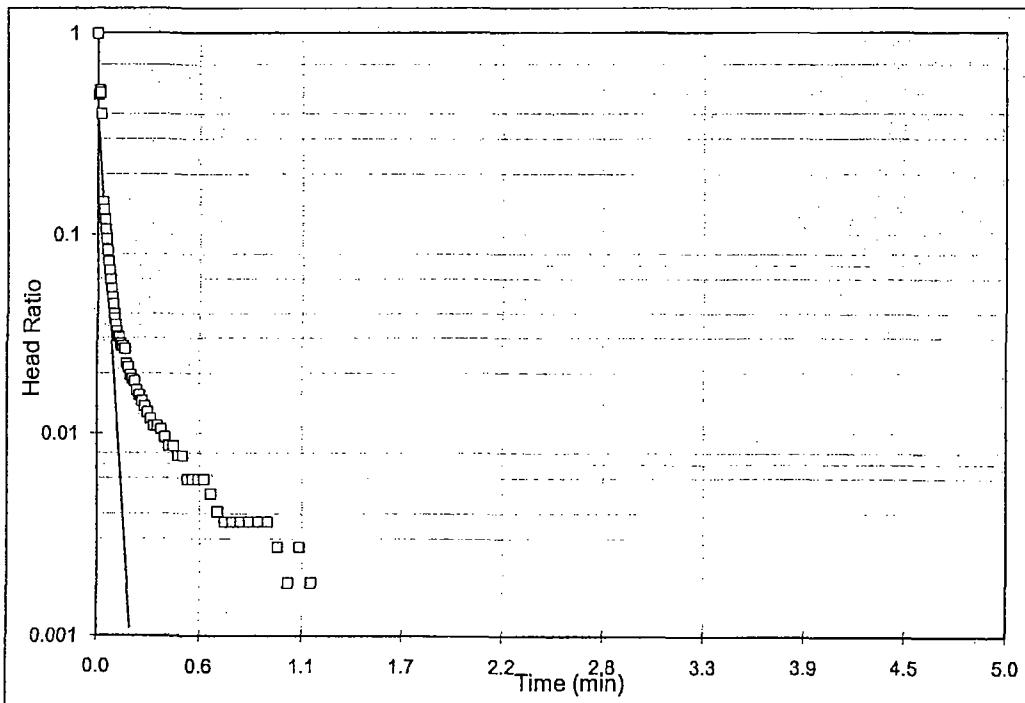
Figure A-15

**HVORSLEV SLUG TEST ANALYSIS  
RISING HEAD TEST NZVI-4**

$$K = \frac{r_c^2}{2L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h_t$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$R_e$ =	0.25	
$L_e$ =	22.0	
$t_1$ =	0.00	$K = 1.18E-02 \text{ cm/sec}$
$t_2$ =	0.18	$K = 3.35E+01 \text{ ft/day}$
$h_{1(t_1)}$ =	0.39	
$h_{2(t_2)}$ =	0.001	



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 11/09/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
RISING HEAD TEST NZVI-4**

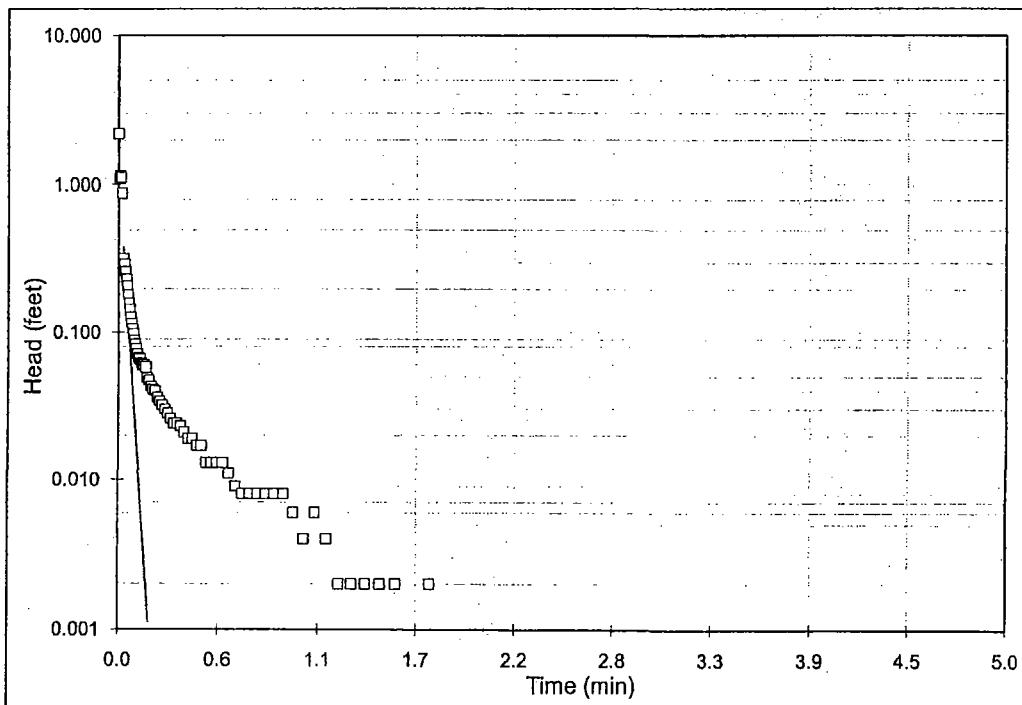
$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{1}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);  
 $R_e$  = effective radius (feet);  
 $L_e$  = length of screened interval (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)  
 $y_0$  = initial drawdown (feet)  
 $y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$r_w$ =	0.25	
$L_e$ =	22	
$\ln(R_e/r_w)$ =	4.66	$K = 1.32E-02 \text{ cm/sec}$
$y_0$ =	0.45	$K = 3.73E+01 \text{ ft/day}$
$y_t$ =	0.001	
$t$ =	0.2	



Project Name: NEASE / OH  
Project No.: 933-6154  
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Analysis By: MJ  
Checked By: FG  
Analysis Date: 2/6/2008

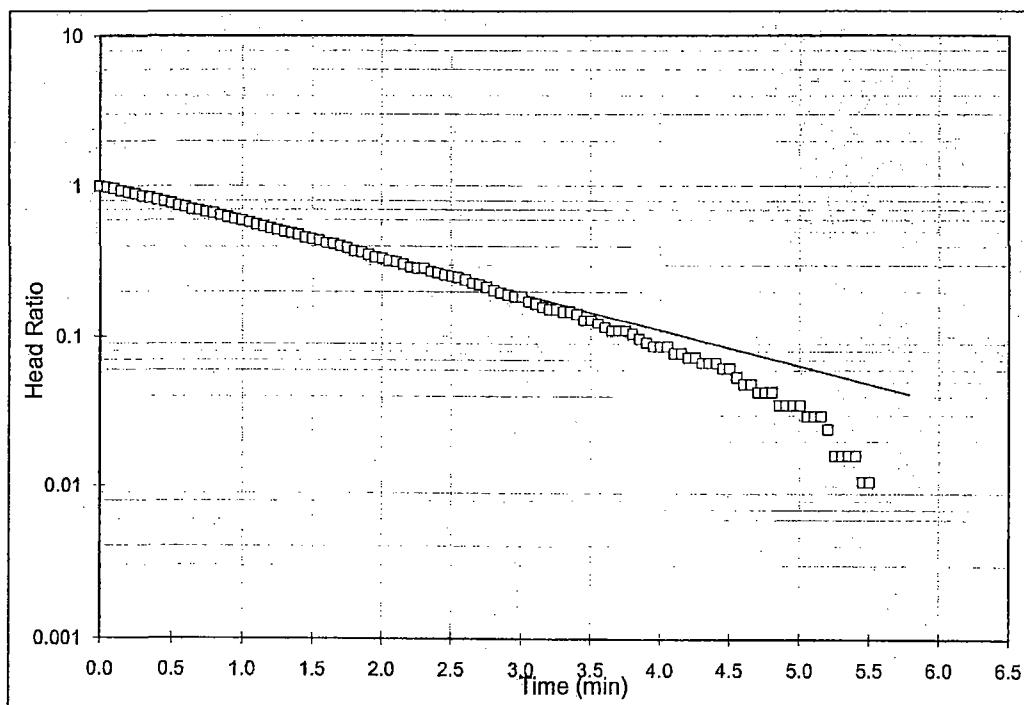
Figure A-17

**HVORSLEV SLUG TEST ANALYSIS  
FALLING HEAD TEST PZ-6B-U**

$$K = \frac{r_c^2}{2L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h_t$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$R_e$ =	0.25	
$L_e$ =	5.0	
$t_1$ =	0.02	$K = 5.83E-04 \text{ cm/sec}$
$t_2$ =	5.78	$K = 1.65E+00 \text{ ft/day}$
$h_{1(t_1)}$ =	1.00	
$h_{2(t_2)}$ =	0.042	



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 09/22/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
FALLING HEAD TEST PZ-6B-U**

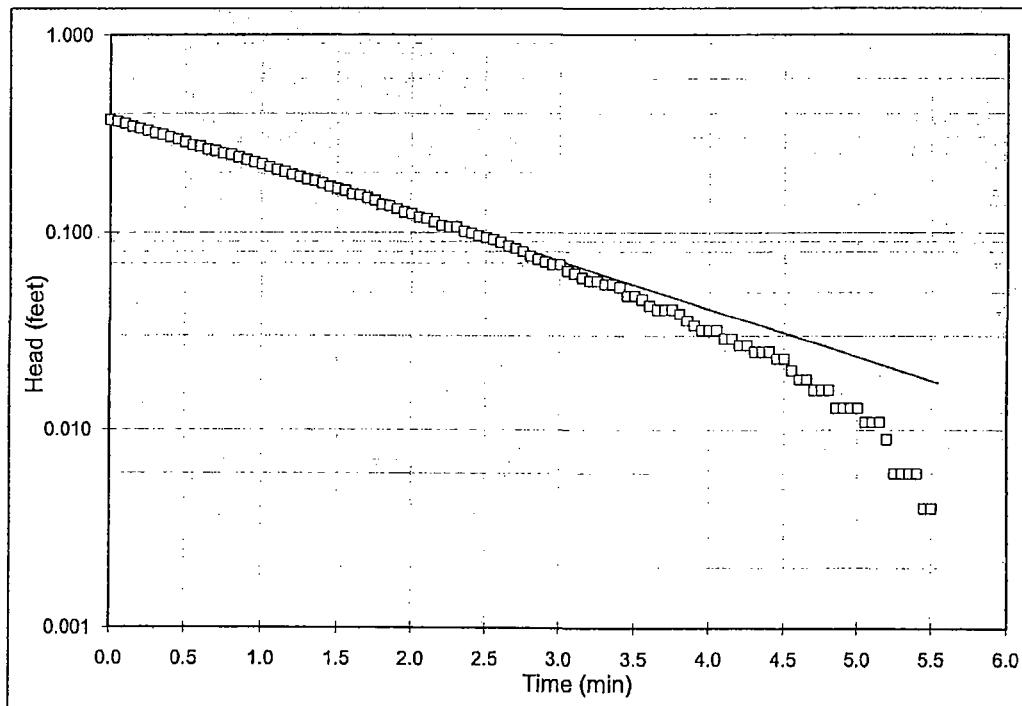
$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{1}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);  
 $R_e$  = effective radius (feet);  
 $L_e$  = length of screened interval (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)  
 $y_0$  = initial drawdown (feet)  
 $y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$r_w$ =	0.25	
$L_e$ =	5	
$\ln(R_e/r_w)$ =	2.28	$K = 4.50E-04 \text{ cm/sec}$
$y_0$ =	0.39	$K = 1.27E+00 \text{ ft/day}$
$y_t$ =	0.017	
$t$ =	5.5	



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 09/22/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

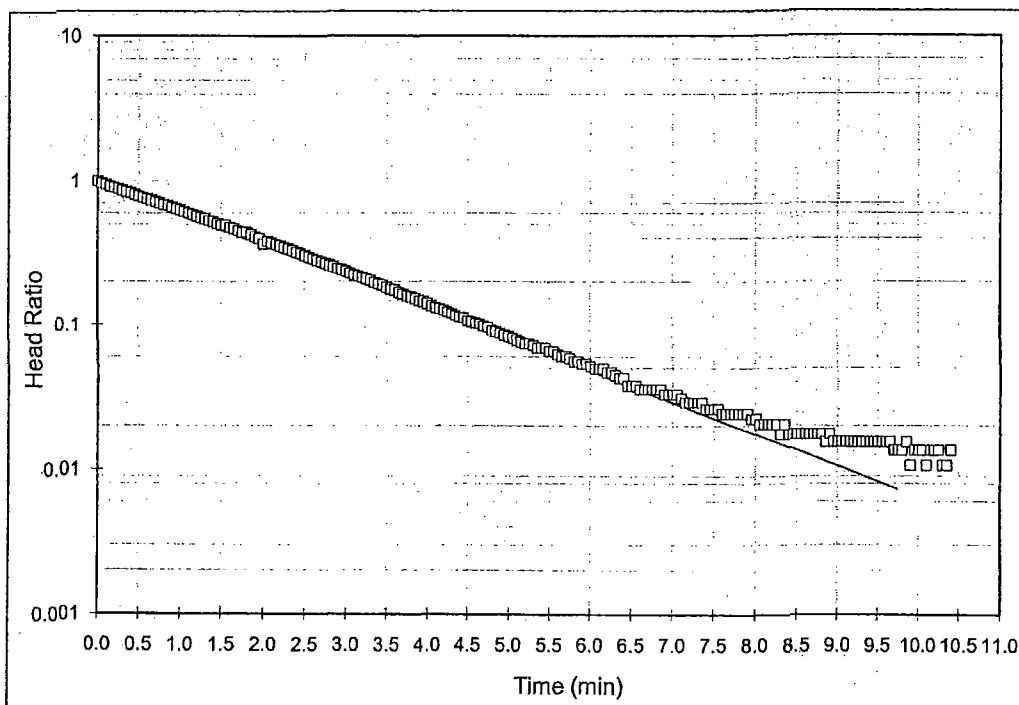
Figure A-19

**HVORSLEV SLUG TEST ANALYSIS  
RISING HEAD TEST PZ-6B-U**

$$K = \frac{r_c^2}{2L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h_t$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$R_e$ =	0.25	
$L_e$ =	5.0	
$t_1$ =	0.02	$K = 5.30E-04 \text{ cm/sec}$
$t_2$ =	9.74	$K = 1.50E+00 \text{ ft/day}$
$h_{1(t_1)}$ =	0.96	
$h_{2(t_2)}$ =	0.007	



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 09/22/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
RISING HEAD TEST PZ-6B-U**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{1}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)

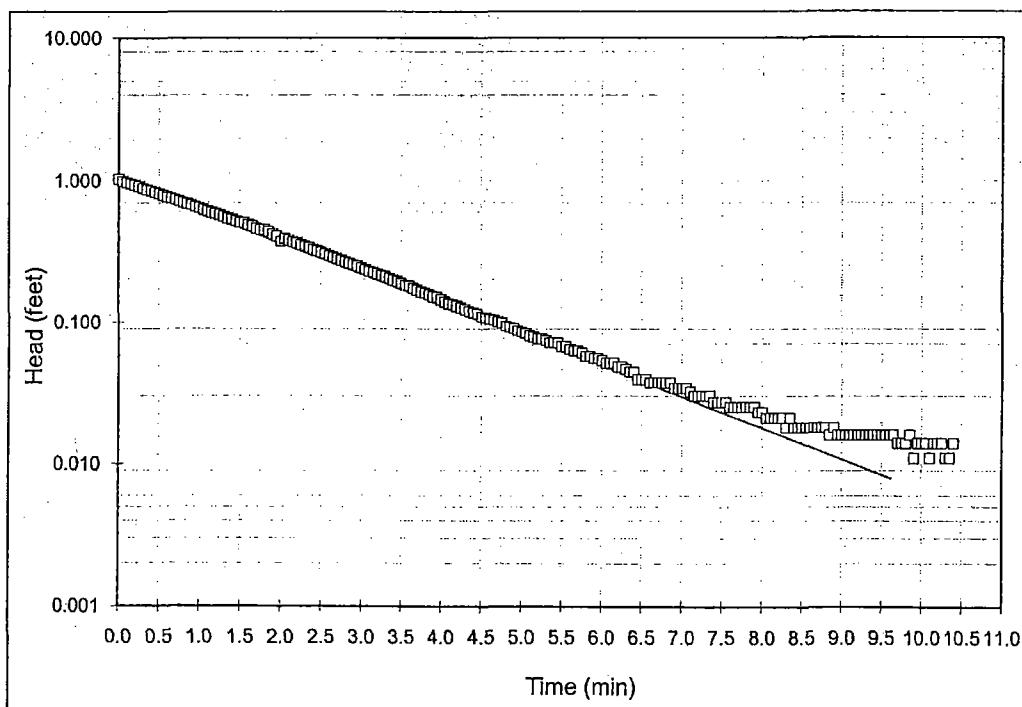
$R_e$  = effective radius (feet);

$y_0$  = initial drawdown (feet)

$L_e$  = length of screened interval (feet);

$y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$r_w$ =	0.25	
$L_e$ =	5	
$\ln(R_e/r_w)$ =	2.28	$K = 4.04E-04 \text{ cm/sec}$
$y_0$ =	1.00	$K = 1.14E+00 \text{ ft/day}$
$y_t$ =	0.008	
$t$ =	9.6	



Project Name: NEASE / OH

Analysis By: MJ

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Checked By: FG

Test Date: 09/22/06

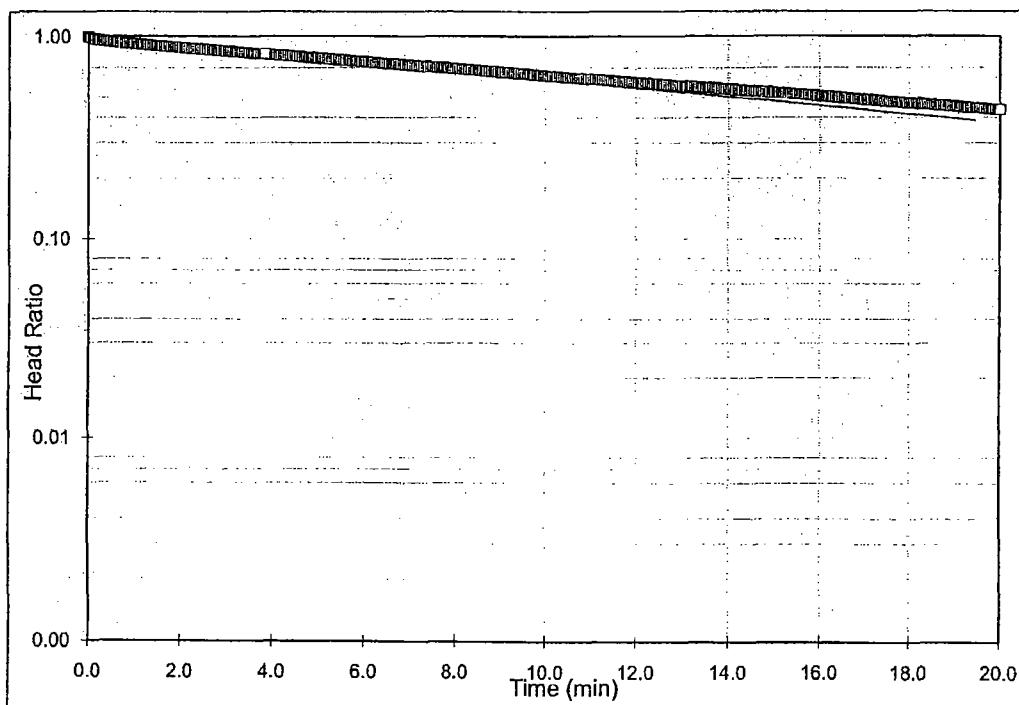
Analysis Date: 2/6/2008

**HVORSLEV SLUG TEST ANALYSIS  
FALLING HEAD TEST NZVI-4**

$$K = \frac{r_c^2}{2L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h_t$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS	
$r_c$ =	0.08	$K =$	4.11E-05 cm/sec
$R_e$ =	0.25	$K =$	1.16E-01 ft/day
$L_e$ =	7.0		
$t_1$ =	0.00		
$t_2$ =	19.45		
$h_{1(t1)}$ =	1.00		
$h_{2(t2)}$ =	0.386		



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 11/08/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
FALLING HEAD TEST NZVI-4**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{I}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)

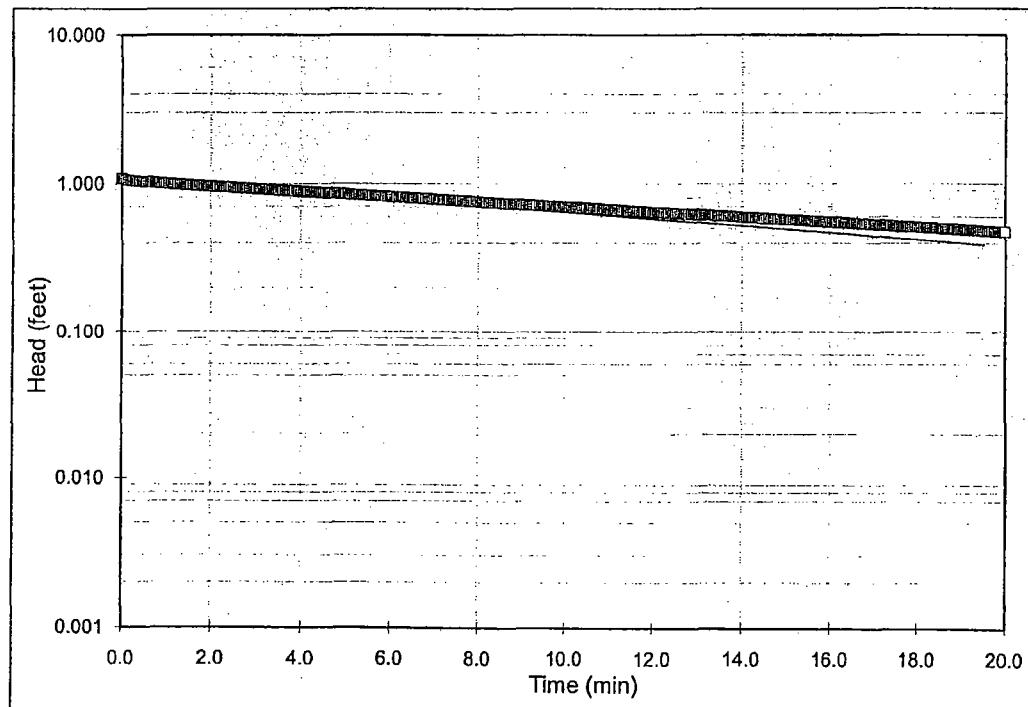
$R_e$  = effective radius (feet);

$y_0$  = initial drawdown (feet)

$L_e$  = length of screened interval (feet);

$y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS		RESULTS	
$r_c$ =	0.08		
$r_w$ =	0.25		
$L_e$ =	7		
$\ln(R_e/r_w)$ =	3.37	$K =$	4.51E-05 cm/sec
$y_0$ =	1.10	$K =$	1.28E-01 ft/day
$y_t$ =	0.389		
$t$ =	19.5		



Project Name: NEASE / OH

Analysis By: MJ

Project No.: 933-6154

Checked By: FG

Test Date: 11/08/06

Analysis Date: 2/6/2008

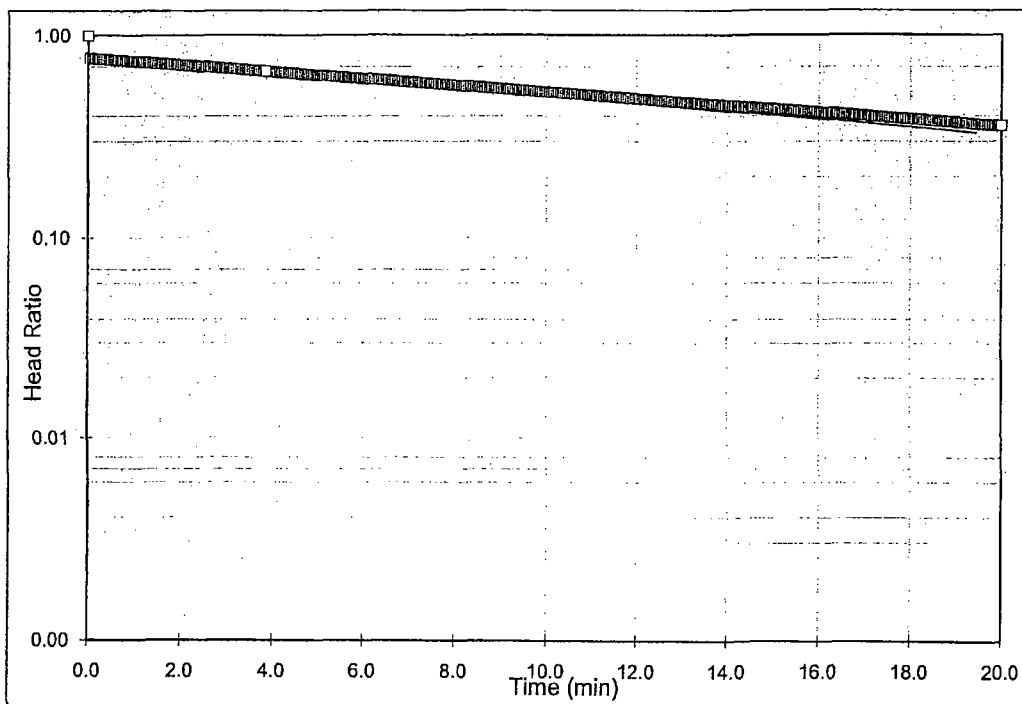
Figure A-23

**HYDROSLEV SLUG TEST ANALYSIS  
RISING HEAD TEST PZ-6B-M**

$$K = \frac{r_c^2}{2 L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h_t$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$R_e$ =	0.25	
$L_e$ =	7.0	
$t_1$ =	0.00	$K = 3.73E-05 \text{ cm/sec}$
$t_2$ =	19.45	$K = 1.06E-01 \text{ ft/day}$
$h_{1(t1)}$ =	0.78	
$h_{2(t2)}$ =	0.330	



Project Name: NEASE / OH

Project No.: 933-6154

Test Date: 11/08/06

Analysis By: MJ

Checked By: FG

Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
RISING HEAD TEST PZ-6B-M**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{1}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)

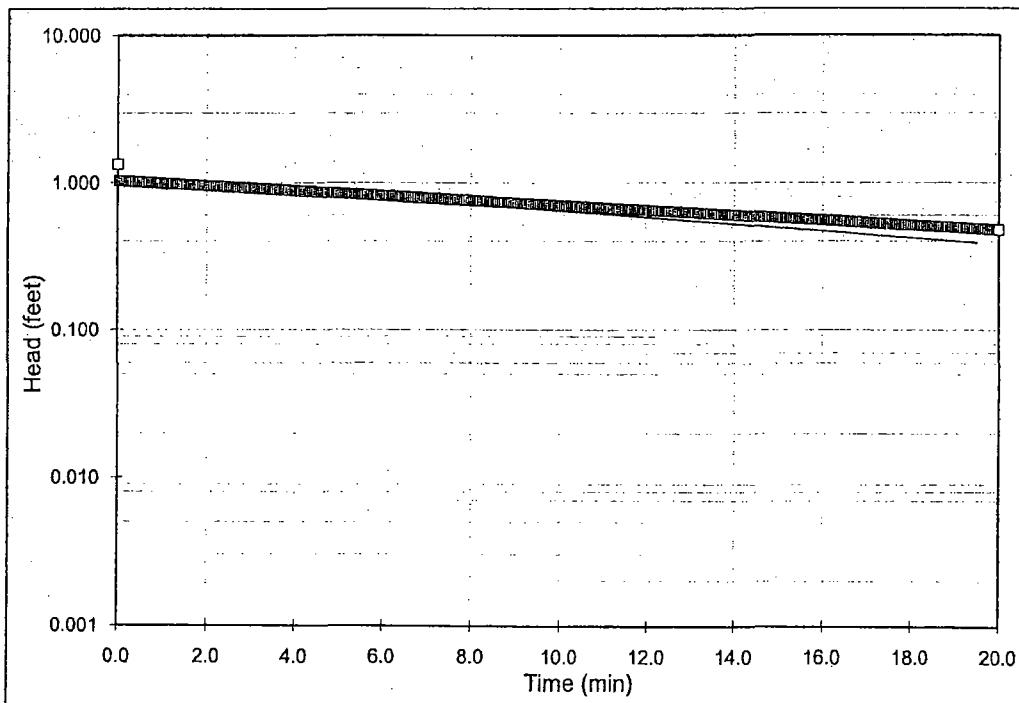
$R_e$  = effective radius (feet);

$y_0$  = initial drawdown (feet)

$L_e$  = length of screened interval (feet);

$y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$r_w$ =	0.25	
$L_e$ =	7	
$\ln(R_e/r_w)$ =	3.37	$K = 4.51E-05 \text{ cm/sec}$
$y_0$ =	1.10	$K = 1.28E-01 \text{ ft/day}$
$y_t$ =	0.389	
$t$ =	19.5	



Project Name: NEASE / OH

Analysis By: MJ

Project No.: 933-6154

Checked By: FG

Test Date: 11/08/06

Analysis Date: 2/6/2008

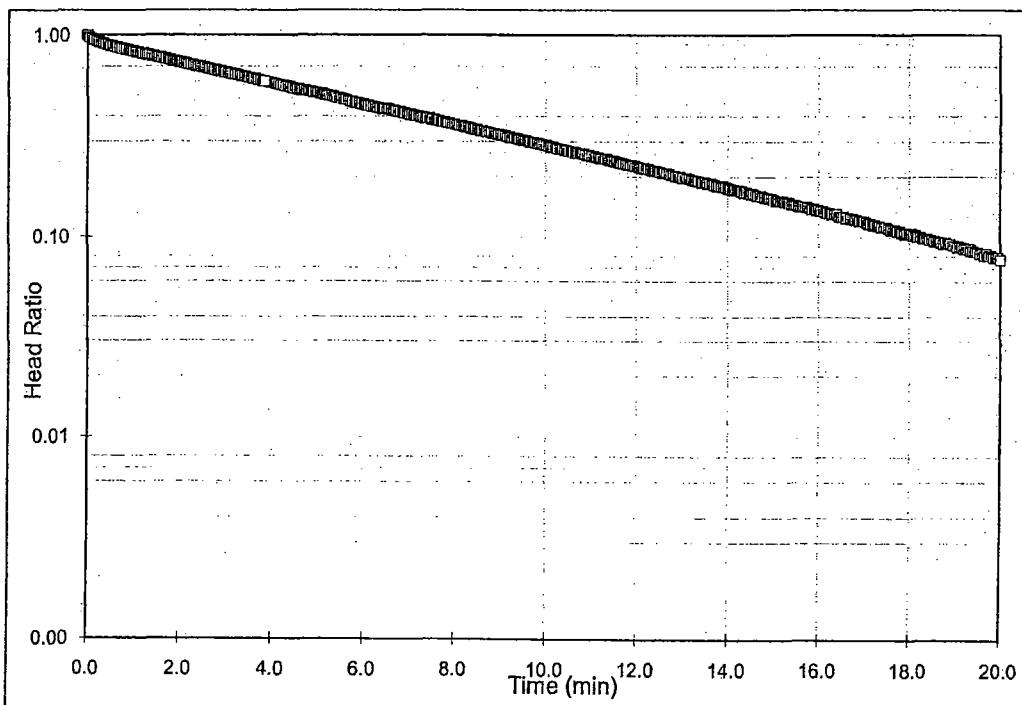
Figure A-25

**HVORSLEV SLUG TEST ANALYSIS  
FALLING HEAD TEST NZVI-4**

$$K = \frac{r_c^2}{2L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h_t$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS	
$r_c$ =	0.08	$K =$	1.02E-04 cm/sec
$R_e$ =	0.25	$K =$	2.90E-01 ft/day
$L_e$ =	7.0		
$t_1$ =	0.00		
$t_2$ =	19.45		
$h_{1(t_1)}$ =	0.98		
$h_{2(t_2)}$ =	0.092		



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 11/07/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
FALLING HEAD TEST NZVI-4**

$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{1}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)

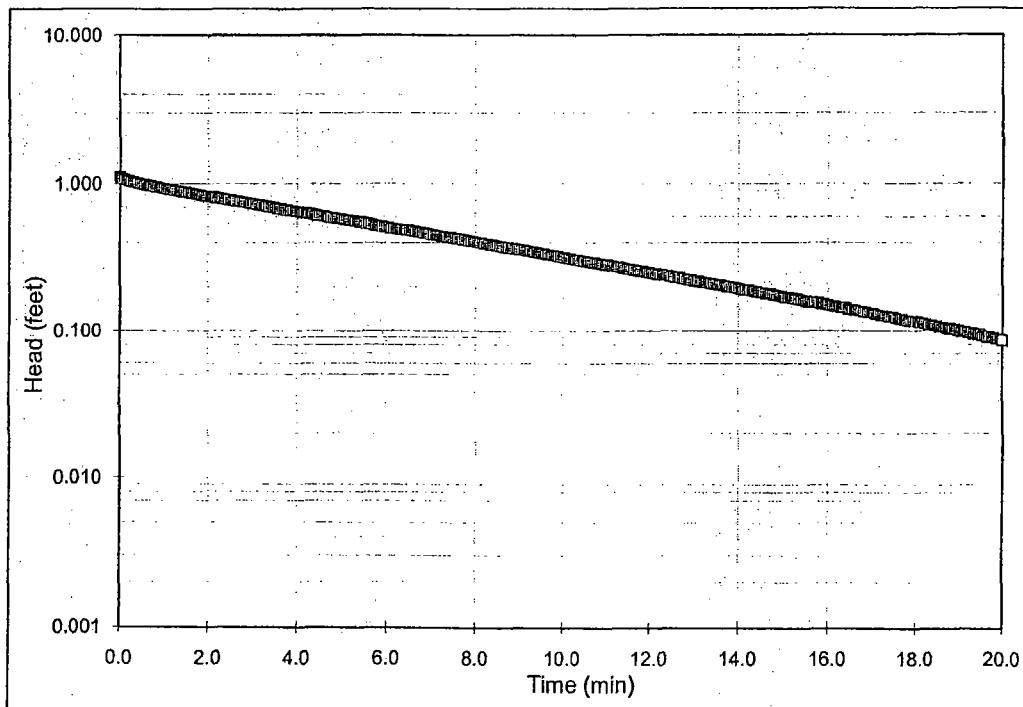
$R_e$  = effective radius (feet);

$y_0$  = initial drawdown (feet)

$L_e$  = length of screened interval (feet);

$y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS	RESULTS
$r_c = 0.08$	
$r_w = 0.25$	
$L_e = 7$	
$\ln(R_e/r_w) = 3.37$	$K = 1.09E-04 \text{ cm/sec}$
$y_0 = 1.10$	$K = 3.09E-01 \text{ ft/day}$
$y_t = 0.089$	
$t = 19.5$	



Project Name: NEASE / OH

Analysis By: MJ

Project No.: 933-6154

Checked By: FG

Test Date: 11/07/06

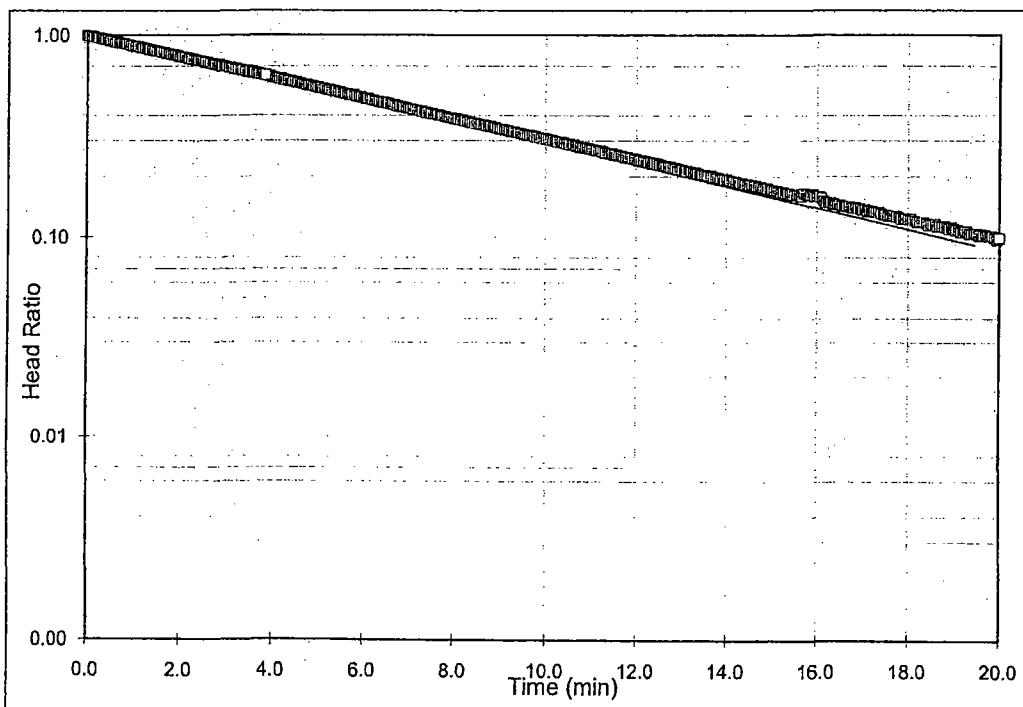
Analysis Date: 2/6/2008

**HVORSLEV SLUG TEST ANALYSIS  
RISING HEAD TEST PZ-6B-L**

$$K = \frac{r_c^2}{2L_e} \ln \frac{L_e}{R_e} \left[ \frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_1 - t_2)} \right]$$

where:  
 $r_c$  = casing radius (feet)  
 $R_e$  = equivalent radius (feet)  
 $L_e$  = length of screened interval (feet)  
 $t$  = time (minutes)  
 $h$  = head at time  $t$  (feet)

INPUT PARAMETERS		RESULTS	
$r_c$ =	0.08	$K =$	1.02E-04 cm/sec
$R_e$ =	0.25	$K =$	2.90E-01 ft/day
$L_e$ =	7.0		
$t_1$ =	0.00		
$t_2$ =	19.45		
$h_{1(t1)}$ =	0.98		
$h_{2(t2)}$ =	0.092		



Project Name: NEASE / OH  
 Project No.: 933-6154  
 Test Date: 11/07/06

Analysis By: MJ  
 Checked By: FG  
 Analysis Date: 2/6/2008

**BOUWER AND RICE SLUG TEST ANALYSIS  
RISING HEAD TEST PZ-6B-L**

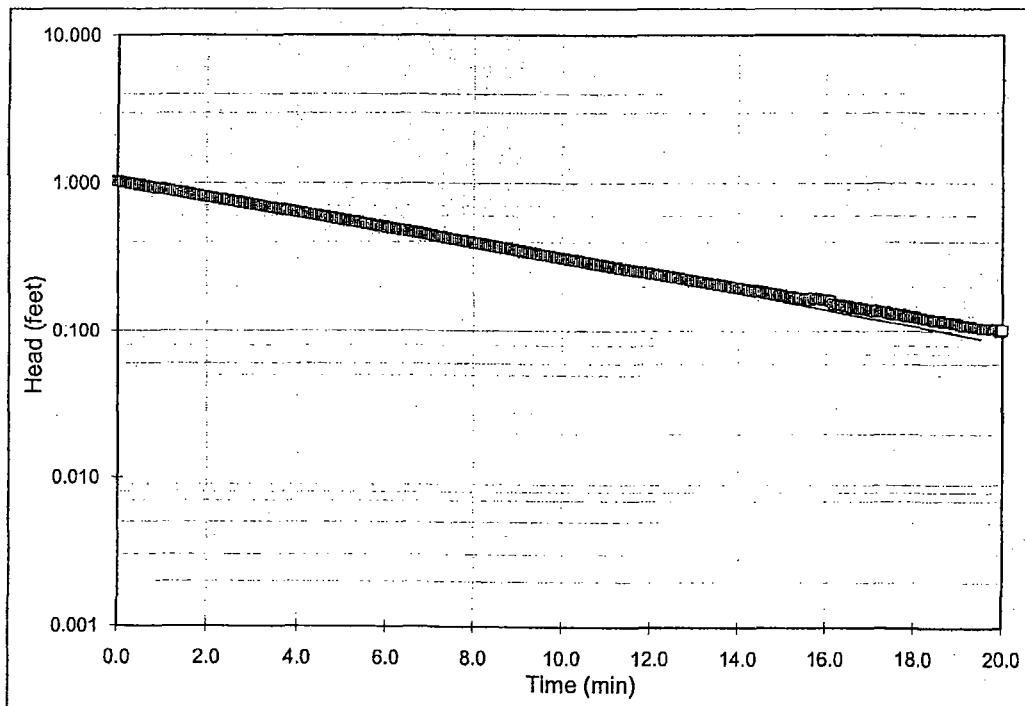
$$K = \frac{r_c^2 \ln\left(\frac{L_e}{R_e}\right)}{2L_e} \frac{I}{t} \ln \frac{y_0}{y_t}$$

where:

$r_c$  = casing radius (feet);  
 $R_e$  = effective radius (feet);  
 $L_e$  = length of screened interval (feet);

$r_w$  = radial distance to undisturbed aquifer (feet)  
 $y_0$  = initial drawdown (feet)  
 $y_t$  = drawdown (feet) at time  $t$  (minutes)

INPUT PARAMETERS		RESULTS
$r_c$ =	0.08	
$r_w$ =	0.25	
$L_e$ =	7	
$\ln(R_e/r_w)$ =	3.37	$K = 1.09E-04 \text{ cm/sec}$
$y_0$ =	1.10	$K = 3.09E-01 \text{ ft/day}$
$y_t$ =	0.089	
$t$ =	19.5	



Project Name: NEASE / OH

Analysis By: MJ

Project No.: 933-6154

Checked By: FG

Test Date: 11/07/06

Analysis Date: 2/6/2008

**APPENDIX B**

**DATALOGGER OUTPUT GRAPHS**

Figure B-1  
Datalogger Monitoring - Water Elevation and ORP  
Monitoring Well NZVI-1

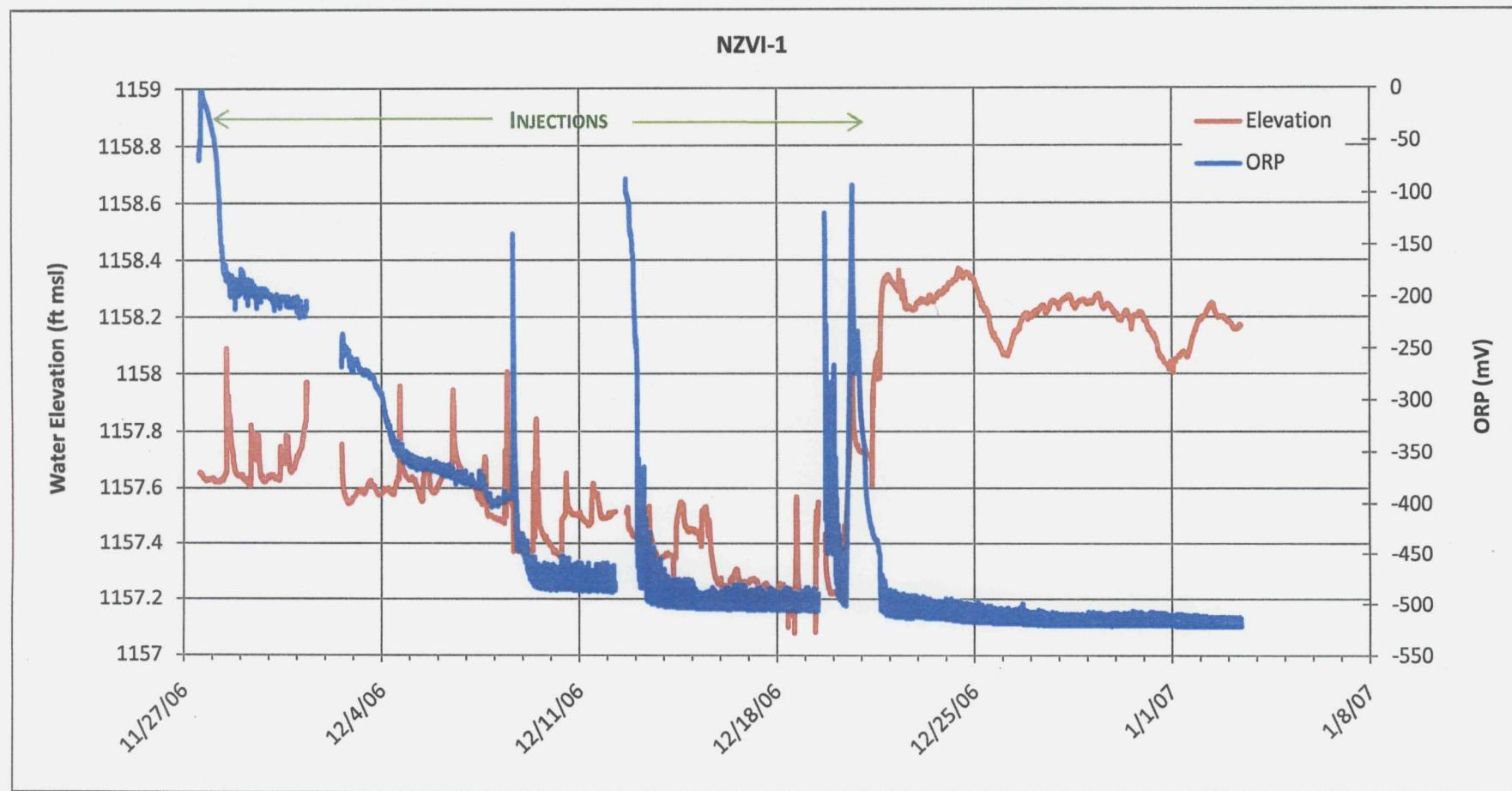


Figure B-2  
Datalogger Monitoring - Water Elevation and ORP  
Monitoring Well NZVI-2

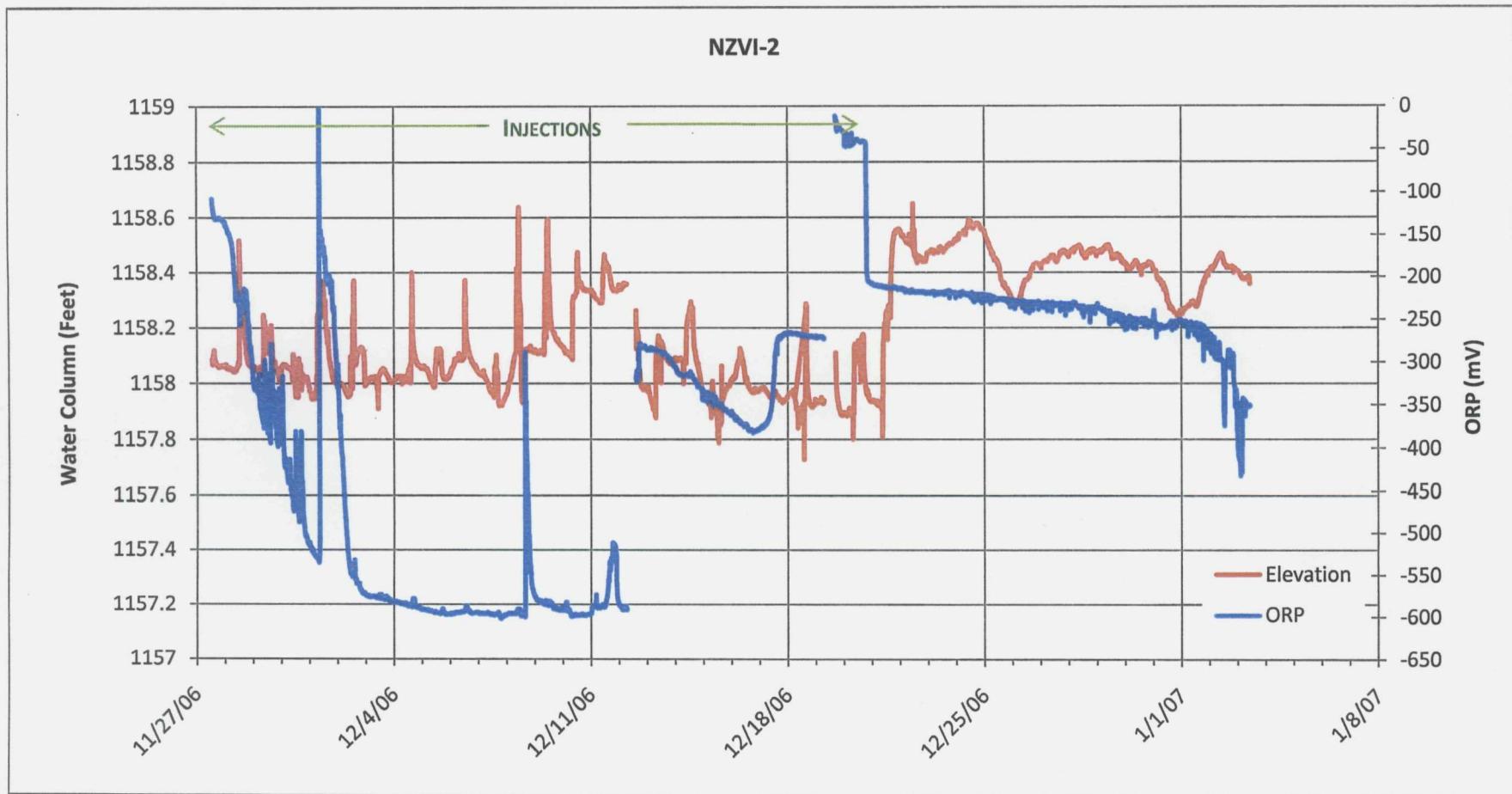


Figure B-3  
Datalogger Monitoring - Water Elevation and ORP  
Monitoring Well NZVI-3

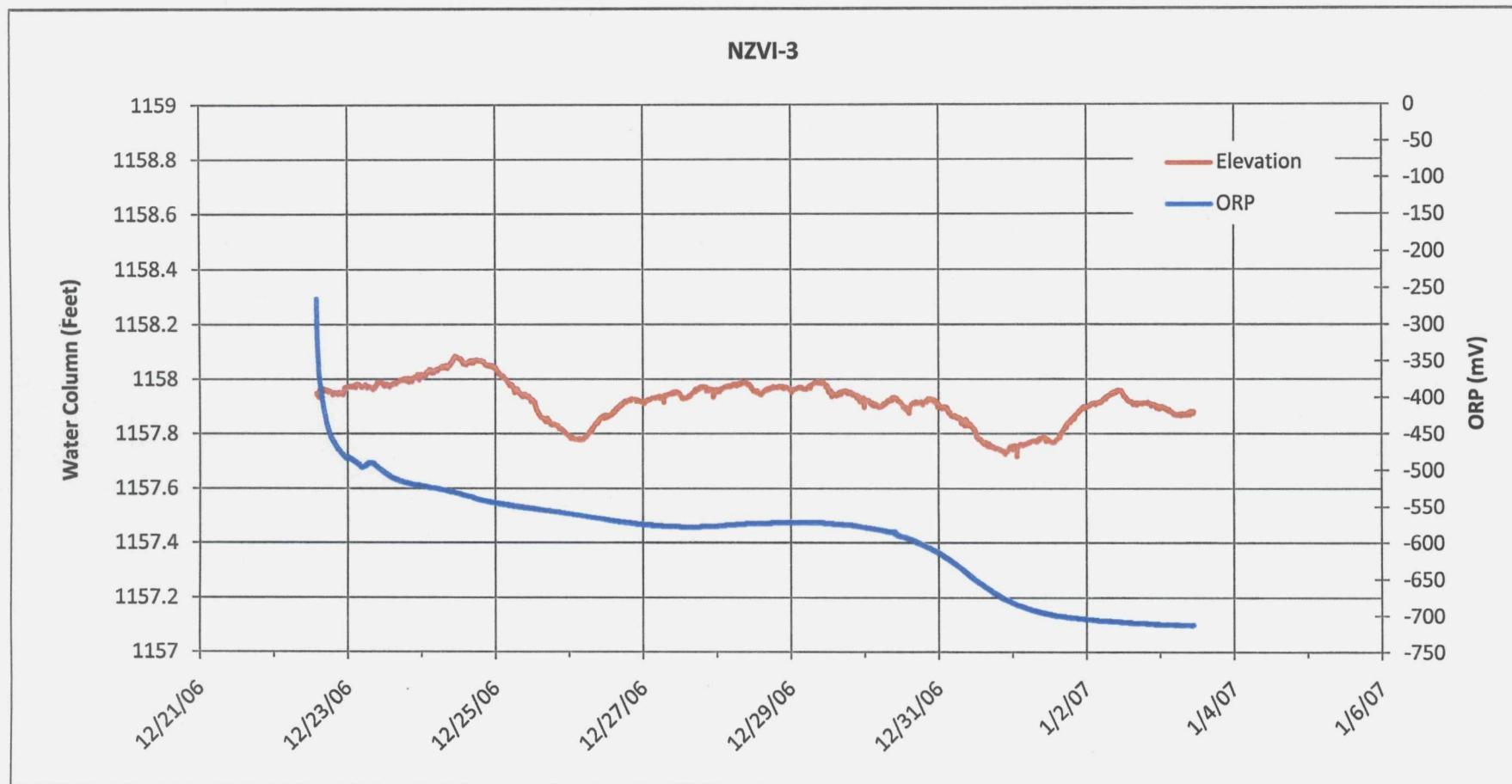


Figure B-4  
Datalogger Monitoring - Water Elevation and ORP  
Monitoring Well NZVI-4

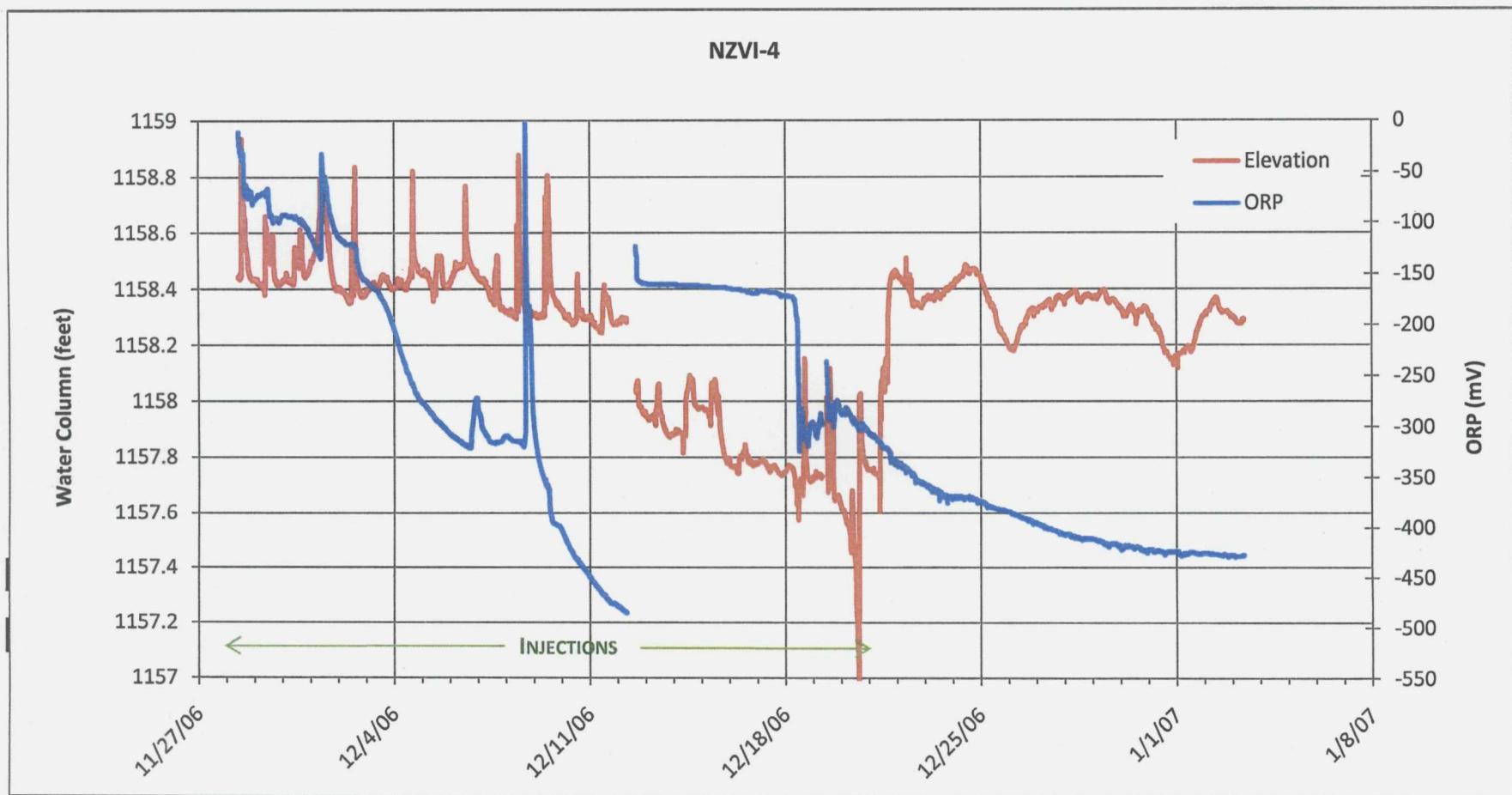
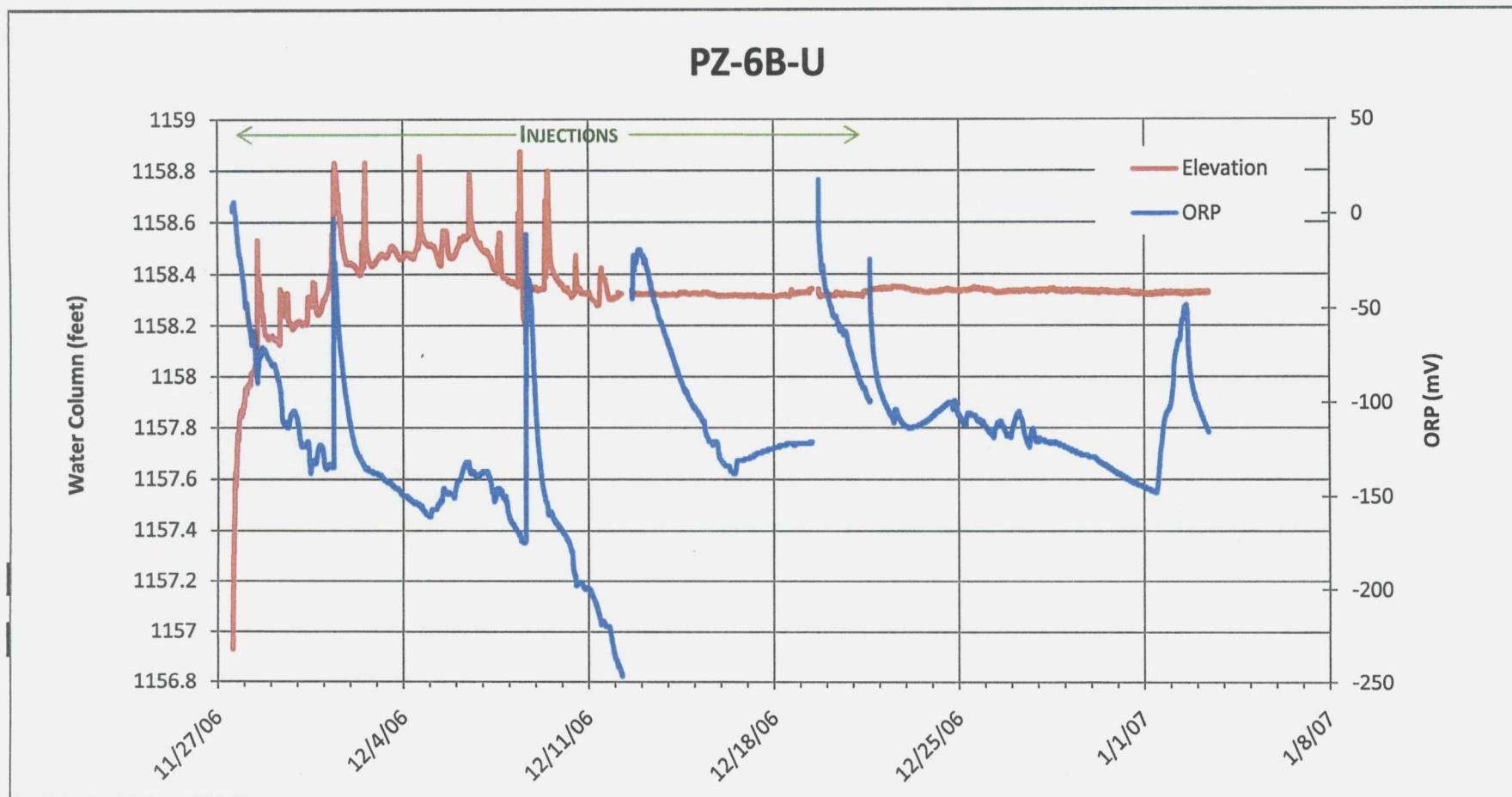


Figure B-5  
Datalogger Monitoring - Water Elevation and ORP  
Monitoring Well PZ-6B-U



**APPENDIX C**

**ANALYTICAL RESULTS**

**Appendix C**  
**NZVI Pilot Test Analytical Results**

sys_loc_code: sample_date: sys_sample_code:		NZVI-1 09/23/2006			NZVI-1 12/12/2006			NZVI-1 12/19/2006			NZVI-1 01/04/2007			NZVI-1 01/31/2007			NZVI-1 02/27/2007		
Parameter	Units	Result	Qual	RL															
<b>Volatile Organic Compounds</b>																			
Acetone	ug/l	<5000	U	5000	<7100	U	7100	<5000	U	5000	<8300	U	8300	<8300	U	8300	<10000	U	10000
Benzene	ug/l	2200		500	2500		710	3600		500	2400		830	3100		830	2300		1000
Bromodichloromethane	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
Bromoform	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
Bromomethane	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
2-Butanone	ug/l	<5000	U	5000	<7100	U	7100	<5000	U	5000	<8300	U	8300	<8300	U	8300	<10000	U	10000
Carbon Disulfide	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
Carbon Tetrachloride	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
Chlorobenzene	ug/l	130	J	500	<710	U	710	200	J	500	<830	U	830	170	J	830	<1000	U	1000
Dibromochloromethane	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
Chloroethane	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
Chloroform	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
Chlormethane	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
1,2-Dichlorobenzene	ug/l	6600		500	7800		710	9800		500	7000		830	9300		830	7200		1000
1,3-Dichlorobenzene	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
1,4-Dichlorobenzene	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
1,1-Dichloroethane	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
1,2-Dichloroethane	ug/l	<500	U	500	<710	U	710	990		500	<830	U	830	830		830	680	J	1000
1,1-Dichloroethene	ug/l	150	J	500	150	J	710	<500	U	500	160	J	830	220	J	830	<1000	U	1000
cis-,2-Dichloroethene	ug/l	16000		500	21000		710	33000		500	23000		830	28000		830	22000		1000
trans-1,2-Dichloroethene	ug/l	570		500	560	J	710	990		500	680	J	830	840		830	660	J	1000
1,2-Dichloropropane	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
cis-,3-Dichloropropene	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
trans-1,3-Dichloropropene	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
Ethylbenzene	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
2-Hexanone	ug/l	<5000	U	5000	<7100	U	7100	<5000	U	5000	<8300	U	8300	<8300	U	8300	<10000	U	10000
Methylene Chloride	ug/l	<500	U	500	<710	U	710	1900		500	<830	U	830	<830	U	830	<1000	U	1000
4-Methyl-2-pentanone	ug/l	<5000	U	5000	<7100	U	7100	<5000	U	5000	<8300	U	8300	<8300	U	8300	<10000	U	10000
Styrene	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
1,1,2,2-Tetrachloroethane	ug/l	730		500	700	J	710	860		500	680	J	830	720	J	830	620	J	1000
Tetrachloroethene	ug/l	10000		500	5600		710	7500		500	4300		830	6500		830	4800		1000
Toluene	ug/l	100	J	500	<710	U	710	150	J	500	<830	U	830	<830	U	830	<1000	U	1000
1,2,4-Trichlorobenzene	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
1,1,1-Trichloroethane	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
1,1,2-Trichloroethane	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
Trichloroethene	ug/l	2500		500	2100		710	3000		500	1500		830	2900		830	2300		1000
Vinyl Chloride	ug/l	<500	U	500	<710	U	710	<500	U	500	<830	U	830	<830	U	830	<1000	U	1000
Xylenes, Total	ug/l	<1000	U	1000	<1400	U	1400	<1000	U	1000	<1700	U	1700	<1700	U	1700	<2000	U	2000

		NZVI-1 09/23/2006			NZVI-1 12/12/2006			NZVI-1 12/19/2006			NZVI-1 01/04/2007			NZVI-1 01/31/2007			NZVI-1 02/27/2007		
		Parameter	Units	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	
<b>Volatile Organic Compounds</b>																			
<b>Natural Attenuation Parameters</b>																			
Acetylene	ug/l						<0.5	J	0.5							<0.5	U	0.5	
Methane	ug/l	73	0.1				81	0.1		87	0.1		94	0.1		100	0.1		
Ethane	ug/l	0.19	0.025				52	0.025		16	0.025		11	0.025		1.9	0.025		
Ethene	ug/l	16	0.025				19	0.025		17	0.025		19	0.025		18	0.025		
Total Suspended Solids	mg/l	17	4							17	4					14	4		
Chloride	mg/l	266	2													266	2		
Nitrite	mg/l	0.2	0.1							<0.1	U	0.1				0.43	0.1		
Nitrate	mg/l	<0.10	U	0.1						<0.1	U	0.1				<0.1	U	0.1	
Sulfate	mg/l	323	2							189	1					191	1		
Alkalinity, Total	mg/l	250	5							260	5					230	J	5	
Phosphorus	mg/l	<0.1	U	0.1						<0.1	U	0.1				<0.1	U	0.1	
Sulfide	mg/l	<1.0	U	1						<1	U	1				<1	U	1	
Total Organic Carbon	mg/l	83	4	76	2		85	4		92	4		79	4		85	2		
<b>Field Parameters</b>																			
Temperature	deg c	14.2		12.8			12.1			16.8			11.5			11.1			
Specific Conductance	ms/cm	1.63		1.76			1.71			1.69			1.68			1.72			
pH	pH units	6.73		6.58			6.73			7.17			8.2			6.86			
Turbidity	ntu	2.1		32.3			4.8			0			0			4.6			
Dissolved Oxygen	mg/l	0		0			0			0			0.37			0.42			
Oxidation-Reduction Potential	millivolts	-145		-107			-118			-111			-90			-16			
Ferrous Iron	ppm	2.4																	

		sys_loc_code: sample_date: sys_sample_code:			NZVI-1 05/01/2007			NZVI-2 09/24/2006			NZVI-2 12/12/2006			NZVI-2 12/19/2006			NZVI-2 01/03/2007		
Parameter	Units	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL
<b>Volatile Organic Compounds</b>																			
Acetone	ug/l	<8300	U	8300	<10000	U	10000	<10000	U	10000	<5000	U	5000	<12000	U	12000	<12000	U	12000
Benzene	ug/l	2800		830	6300		1000	5200		1000	6400		500	4800		1200	5600		1200
Bromodichloromethane	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
Bromoform	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
Bromomethane	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
2-Butanone	ug/l	<8300	U	8300	<10000	U	10000	<10000	U	10000	<5000	U	5000	<12000	U	12000	<12000	U	12000
Carbon Disulfide	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
Carbon Tetrachloride	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
Chlorobenzene	ug/l	170	J	830	240	J	1000	260	J	1000	260	J	500	<1200	U	1200	<1200	U	1200
Dibromochloromethane	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
Chloroethane	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
Chloroform	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
Chloromethane	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
1,2-Dichlorobenzene	ug/l	9300		830	15000		1000	14000		1000	16000		500	12000		1200	14000		1200
1,3-Dichlorobenzene	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
1,4-Dichlorobenzene	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	110	J	500	<1200	U	1200	<1200	U	1200
1,1-Dichloroethane	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
1,2-Dichloroethane	ug/l	840		830	<1000	U	1000	<1000	U	1000	1600		500	<1200	U	1200	1200		1200
1,1-Dichloroethene	ug/l	<830	U	830	200	J	1000	190	J	1000	190	J	500	<1200	U	1200	240	J	1200
cis-1,2-Dichloroethene	ug/l	25000		830	23000		1000	25000		1000	35000		500	26000		1200	27000		1200
trans-1,2-Dichloroethene	ug/l	770	J	830	750	J	1000	820	J	1000	910		500	590	J	1200	680	J	1200
1,2-Dichloropropane	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
cis-1,3-Dichloropropane	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
trans-1,3-Dichloropropane	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
Ethylbenzene	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
2-Hexanone	ug/l	<8300	U	8300	<10000	U	10000	<10000	U	10000	<5000	U	5000	<12000	U	12000	<12000	U	12000
Methylene Chloride	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	1800		500	<1200	U	1200	<1200	U	1200
4-Methyl-2-pentanone	ug/l	<8300	U	8300	<10000	U	10000	<10000	U	10000	<5000	U	5000	<12000	U	12000	<12000	U	12000
Styrene	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
1,1,2,2-Tetrachloroethane	ug/l	720	J	830	1800		1000	1500		1000	1400		500	1000	J	1200	1200		1200
Tetrachloroethene	ug/l	5900		830	37000		1000	30000		1000	28000		500	23000		1200	29000		1200
Toluene	ug/l	<830	U	830	300	J	1000	270	J	1000	240	J	500	<1200	U	1200	<1200	U	1200
1,2,4-Trichlorobenzene	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
1,1,1-Trichloroethane	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
1,1,2-Trichloroethane	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
Trichloroethene	ug/l	3200		830	8600		1000	8400		1000	12000		500	6100		1200	7100		1200
Vinyl Chloride	ug/l	<830	U	830	<1000	U	1000	<1000	U	1000	<500	U	500	<1200	U	1200	<1200	U	1200
Xylenes, Total	ug/l	<1700	U	1700	<2000	U	2000	<2000	U	2000	<1000	U	1000	<2500	U	2500	<2500	U	2500

		NZVI-1 05/01/2007	NZVI-2 09/24/2006			NZVI-2 12/12/2006			NZVI-2 12/19/2006			NZVI-2 01/03/2007			NZVI-2 01/30/2007		
Parameter	Unit	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	
<b>Volatile Organic Compounds</b>																	
<b>Natural Attenuation Parameters</b>																	
Acetylene	µg/l								6.4	0.5							
Methane	µg/l	100	0.1	37	0.1				63	0.1	70	0.1	70	0.1			
Ethane	µg/l	1.4	0.025	0.096	0.025				98	0.025	17	0.025	34	0.025			
Ethene	µg/l	19	0.025	12	0.025				21	0.025	14	0.025	15	0.025			
Total Suspended Solids	mg/l	19	4	11	4						24	4					
Chloride	mg/l	255	5	226	2												
Nitrite	mg/l	0.66	J	0.1	0.26	J-	0.1				0.5	0.1					
Nitrate	mg/l	<0.1	UJ	0.1	<0.10	R	0.1				<0.1	U	0.1				
Sulfate	mg/l	157	1	144	1						66.6	1					
Alkalinity, Total	mg/l	250	J	5	250	5					260	5					
Phosphorus	mg/l	<0.1	U	0.1	<0.1	U	0.1				<0.1	U	0.1				
Sulfide	mg/l	<1	U	1	<1.0	U	1				<1	U	1				
Total Organic Carbon	mg/l	83	4	68	J+	4	71	2	66	4	57	4	61	4			
<b>Field Parameters</b>																	
Temperature	deg c	13.68		13.3		11.4		11.4		16			10.4				
Specific Conductance	ms/cm	1.42		1.32		1.42		1.3		1.37			1.38				
pH	pH Units	6.66		6.82		6.54		6.72		7.43			8.72				
Turbidity	ntu	71.4		24.3		3		0		30.5			0				
Dissolved Oxygen	mg/l	0		0		5.96		0		0			0.57				
Oxidation-Reduction Potential	millivolts	-76		-159		-158		-164		-93			-90				
Ferrous Iron	ppm			2													

**Appendix C**  
**NZVI Pilot Test Analytical Results**

		NZVI-2 02/28/2007			NZVI-2 05/01/2007			NZVI-3 09/24/2006			NZVI-3 01/04/2007			NZVI-3 01/04/2007			NZVI-3 01/31/2007			
		sys_loc_code:	sample_date:	sys_sample_code:	NZVI-2_050107_PA7B280225005	NZVI-2_050107_PA7E020224002	NZVI-3_A6I260132006	NZVI-3_010407_DA'AO40267003	NZVI-3_010407_PA7A040267002	NZVI-3_013107_PA7A310293002										
Parameter	Units	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	
<b>Volatile Organic Compounds</b>																				
Acetone	ug/l	<10000	U	10000	<8300	U	8300	<14000	U	14000	<7100	U	7100	<7100	U	7100	<8300	U	8300	
Benzene	ug/l	5100		1000	5400		830	4000		1400	5300		710	4900		710	6300		830	
Bromodichloromethane	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
Bromoform	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
Bromomethane	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
2-Butanone	ug/l	<10000	U	10000	<8300	U	8300	<14000	U	14000	<7100	U	7100	<7100	U	7100	<8300	U	8300	
Carbon Disulfide	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
Carbon Tetrachloride	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
Chlorobenzene	ug/l	200	J	1000	240	J	830	<1400	U	1400	330	J	710	280	J	710	390	J	830	
Dibromochloromethane	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
Chloroethane	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	170	J	710	200	J	710	<830	U	830	
Chloroform	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
Chloromethane	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
1,2-Dichlorobenzene	ug/l	13000		1000	14000		830	12000		1400	9500		710	8600		710	13000		830	
1,3-Dichlorobenzene	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
1,4-Dichlorobenzene	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
1,1-Dichloroethane	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
1,2-Dichloroethane	ug/l	1200		1000	1400		830	<1400	U	1400	<710	U	710	<710	U	710	1200		830	
1,1-Dichloroethylene	ug/l	180	J	1000	<830	U	830	<1400	U	1400	160	J	710	160	J	710	210	J	830	
cis-1,2-Dichloroethene	ug/l	23000		1000	23000		830	18000		1400	17000		710	17000		710	26000		830	
trans-1,2-Dichloroethene	ug/l	660	J	1000	760	J	830	1200	J	1400	630	J	710	510	J	710	950		830	
1,2-Dichloropropane	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
cis-1,3-Dichloropropene	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
trans-1,3-Dichloropropene	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
Ethylbenzene	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
2-Hexanone	ug/l	<10000	U	10000	<8300	U	8300	<14000	U	14000	<7100	U	7100	<7100	U	7100	<8300	U	8300	
Methylene Chloride	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
4-Methyl-2-pentanone	ug/l	<10000	U	10000	<8300	U	8300	<14000	U	14000	<7100	U	7100	<7100	U	7100	<8300	U	8300	
Styrene	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
1,1,2,2-Tetrachloroethane	ug/l	1200		1000	1400		830	1000	J	1400	1500		710	1400		710	1800		830	
Tetrachloroethene	ug/l	29000		1000	28000		830	42000		1400	16000		710	15000		710	24000		830	
Toluene	ug/l	170	J	1000	180	J	830	430	J	1400	430	J	710	400	J	710	550	J	830	
1,2,4-Trichlorobenzene	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
1,1,1-Trichloroethane	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
1,1,2-Trichloroethane	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	<710	U	710	<710	U	710	<830	U	830	
Trichloroethylene	ug/l	7200		1000	7200		830	10000		1400	6800		710	6300		710	9900		830	
Vinyl Chloride	ug/l	<1000	U	1000	<830	U	830	<1400	U	1400	220	J	710	220	J	710	<830	U	830	
Xylenes, Total	ug/l	<2000	U	2000	<1700	U	1700	<2900	U	2900	<1400	U	1400	<1400	U	1400	<1700	U	1700	

Parameter	Units	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL
<b>Volatile Organic Compounds</b>																
<b>Natural Attenuation Parameters</b>																
Acetylene	ug/l	<0.5	U	0.5							15	0.5	2.4	0.5	62	0.5
Methane	ug/l	75	0.1		92	0.1		66	0.1		190	0.1	180	0.1	190	0.1
Ethane	ug/l	9.9	0.025		11	0.025		0.73	0.025		5200	0.25	5000	0.25	3500	J 0.5
Ethene	ug/l	15	0.025		18	0.025		27	0.025		550	0.25	530	0.25	290	0.025
Total Suspended Solids	mg/l	17	4		13	4		15	4		230	8	260	8		
Chloride	mg/l	217	2		197	5		319	5							
Nitrite	mg/l	0.42	0.1		0.58	J	0.1	0.55	J-	0.1	<0.1	U	0.1	<0.1	U	0.1
Nitrate	mg/l	<0.1	U	0.1	<0.1	UJ	0.1	<0.10	R	0.1	<0.1	U	0.1	<0.1	U	0.1
Sulfate	mg/l	51.7	1		43.8	1		254	5		76.3	1	76.8	1		
Alkalinity, Total	mg/l	240	J	5	260	J	5	250	5		220	5	220	5		
Phosphorus	mg/l	<0.1	U	0.1	<0.1	U	0.1	<0.1	U	0.1	<0.1	U	0.1	<0.1	U	0.1
Sulfide	mg/l	<1	U	1	<1	U	1	2	1		2.4	1	1.1	1		
Total Organic Carbon	mg/l	50	1		56	4		120	J+	10	140	4	140	10	150	10
<b>Field Parameters</b>																
Temperature	deg c	12.1			14.76			13.9					17.4		12.3	
Specific Conductance	ms/cm	1.35			1.07			1.94					1.55		1.66	
pH	pH units	6.89			6.69			7.04					8.32		9.7	
Turbidity	ntu	28.4			7.8			16					50.5		0	
Dissolved Oxygen	mg/l	0.29			0			0					0		1.72	
Oxidation-Reduction Potential	millivolts	-36			-76			-140					-308		-196	
Ferric Iron	ppm							2.1								

	<b>sys_loc_code:</b> sample_date: <b>sys_sample_code:</b>	NZVI-3 03/01/2007			NZVI-3 05/02/2007			NZVI-4 11/07/2006			NZVI-4 12/12/2006			NZVI-4 12/19/2006			NZVI-4 01/03/2007		
Parameter	Units	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL									
<b>Volatile Organic Compounds</b>																			
Acetone	ug/l	<10000	U	10000	840	U	10000	<17000	U	17000	<12000	U	12000	<2000	U	2000	<17000	U	17000
Benzene	ug/l	5100	1000		5300	1000		5200		1700	4700		1200	2200		200	4700		1700
Bromodichloroethane	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
Bromoform	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
Bromomethane	ug/l	<1000	U	1000	<1000	U	10000	<17000	U	17000	<12000	U	12000	<2000	U	2000	<17000	U	17000
2-Butanone	ug/l	<10000	U	10000	<10000	U	10000	<17000	U	17000	<12000	U	12000	<2000	U	2000	<17000	U	17000
Carbon Disulfide	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
Carbon Tetrachloride	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
Chlorobenzene	ug/l	330	J	1000	330	J	1000	<1700	U	1700	<1200	U	1200	120	J	200	<1700	U	1700
Dibromochloromethane	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
Chloroethane	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
Chloroform	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
Chloromethane	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
1,2-Dichlorobenzene	ug/l	16000		1000	14000		1000	16000		1700	12000		1200	4600		200	12000		1700
1,3-Dichlorobenzene	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
1,4-Dichlorobenzene	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
1,1-Dichloroethane	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
1,2-Dichloroethane	ug/l	<1000	U	1000	1200		1000	<1700	U	1700	<1200	U	1200	490		200	<1700	U	1700
1,1-Dichloroethene	ug/l	220	J	1000	240	J	1000	<1700	U	1700	300	J	1200	<200	U	200	320	J	1700
cis-1,2-Dichloroethylene	ug/l	32000		1000	34000		1000	20000		1700	35000		1200	14000		200	41000		1700
trans-1,2-Dichloroethylene	ug/l	980	J	1000	1200		1000	1100	J	1700	920	J	1200	300		200	930	J	1700
1,2-Dichloropropane	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
cis-1,3-Dichloropropene	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
trans-1,3-Dichloropropene	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
Ethylbenzene	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
2-Hexanone	ug/l	<10000	U	10000	<10000	U	10000	<17000	U	17000	<12000	U	12000	<2000	U	2000	<17000	U	17000
Methylene Chloride	ug/l	<1000	U	1000	420	U	1000	<1700	U	1700	1200	U	1200	750	U	200	<1700	U	1700
4-Methyl-2-pentanone	ug/l	<10000	U	10000	<10000	U	10000	<17000	U	17000	<12000	U	12000	<2000	U	2000	<17000	U	17000
Styrene	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
1,1,2,2-Tetrachloroethane	ug/l	1700		1000	1900		1000	2200		1700	1600		1200	470		200	1500	J	1700
Tetrachloroethylene	ug/l	23000		1000	19000		1000	42000		1700	9600		1200	2200		200	5100		1700
Toluene	ug/l	490	J	1000	440	J	1000	450	J	1700	390	J	1200	220		200	350	J	1700
1,2,4-Trichlorobenzene	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
1,1,1-Trichloroethane	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
1,1,2-Trichloroethane	ug/l	<1000	U	1000	<1000	U	1000	<1700	U	1700	<1200	U	1200	<200	U	200	<1700	U	1700
Trichloroethene	ug/l	7400		1000	5100		1000	11000		1700	11000		1200	1900		200	3200		1700
Vinyl Chloride	ug/l	<1000	U	1000	290	J	1000	<1700	U	1700	<1200	U	1200	130	J	200	<1700	U	1700
Xylenes, Total	ug/l	<2000	U	2000	<2000	U	2000	<3300	U	3300	<2500	U	2500	<400	U	400	<3300	U	3300

sys_loc_code: sample_date: sys_sample_code:		NZVI-3 03/01/2007			NZVI-3 05/02/2007			NZVI-4 11/07/2006			NZVI-4 12/12/2006			NZVI-4 12/19/2006			NZVI-4 01/03/2007				
Parameter	Units	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL		
<b>Volatile Organic Compounds</b>																					
<b>Natural Attenuation Parameters</b>																					
Acetylene	ug/l	140	0.5	57	0.5												1.9	0.5	7.6	0.5	
Methane	ug/l	190	0.1	180	0.1	95	0.1										67	0.1	98	0.1	
Ethane	ug/l	1100	0.025	2400	J	0.25	0.23	0.025									2000	0.25	1700	0.25	
Ethene	ug/l	260	0.025	260		0.025	27	0.025									190	0.025	180	0.025	
Total Suspended Solids	mg/l	32	4	62	4	6	4												46	4	
Chloride	mg/l	272	5	268	5	247	5														
Nitrite	mg/l	<0.1	UJ	0.1	0.79	0.1	<0.10	U	0.1										0.5	0.1	
Nitrate	mg/l	<0.1	U	0.1	<0.1	U	0.1	<0.10	U	0.1									<0.1	U	0.1
Sulfate	mg/l	66.1	1	60.6	1	100	1												82.8	1	
Alkalinity, Total	mg/l	230	J	5	280	J	10	230	5										220	5	
Phosphorus	mg/l	<0.1	U	0.1	<0.1	U	0.1	<0.1	U	0.1									<0.1	U	0.1
Sulfide	mg/l	<1	U	1	<1	U	1	<1.0	U	1									<1	U	1
Total Organic Carbon	mg/l	8100	1000	180	10	89	4	70	2		140	10	99	10							
<b>Field Parameters</b>																					
Temperature	deg c	11.7		12.99		12.9		12.4			11.5		17.7								
Specific Conductance	ms/cm	1.64		1.62		1.38		1.38			1.15		1.63								
pH	pH units	7.23		7.2		6.85		6.48			6.85		7.87								
Turbidity	ntu	23.9		29.9		0		15.9			32.2		14								
Dissolved Oxygen	mg/l	0.6		0		0		0			0		0								
Oxidation-Reduction Potential	millivolts	-151		-240		-89		-126			-167		-320								
Ferrous Iron	ppm					3															

		sys_loc_code: sample_date: sys_sample_code:			NZVI-4 01/30/2007			NZVI-4 02/28/2007			NZVI-4 05/02/2007			PZ-6B-U 09/24/2006			PZ-6B-U 12/12/2006			PZ-6B-U 12/19/2006		
Parameter	Units	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL
<b>Volatile Organic Compounds</b>																						
Acerone	ug/l	<17000	U	17000	<20000	U	20000	<17000	U	17000	<33000	U	33000	<17000	U	17000	<10000	U	10000			
Benzene	ug/l	5700		1700	5200		2000	5100		1700	7000		3300	5600		1700	5700		5700		1000	
Bromoiodochloromethane	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
Bromoform	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
Bromomethane	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
2-Butanone	ug/l	<17000	U	17000	<20000	U	20000	<17000	U	17000	<33000	U	33000	<17000	U	17000	<10000	U	10000			
Carbon Disulfide	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
Carbon Tetrachloride	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
Chiclobenzene	ug/l	<1700	U	1700	<2000	U	2000	360	J	1700	<3300	U	3300	370	J	1700	300	J	1000			
Dibromo-chloromethane	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
Chloroethane	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
Chloroform	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
Chlormethane	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
1,2-Dichlorobenzene	ug/l	15000		1700	16000		2000	16000		1700	18000		3300	16000		1700	16000		16000		1000	
1,3-Dichlorobenzene	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
1,4-Dichlorobenzene	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
1,1-Dichloroethane	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
1,2-Dichloroethane	ug/l	1100	J	1700	1100	J	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	1400		1000			
1,1-Dichloroethene	ug/l	300	J	1700	460	J	2000	340	J	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
cis-1,2-Dichloroethene	ug/l	45000		1700	44000		2000	40000		1700	14000		3300	27000		1700	29000		1000			
trans-1,2-Dichloroether	ug/l	1000	J	1700	1100	J	2000	1000	J	1700	2200	J	3300	1800		1700	2000		1000			
1,2-Dichloropropane	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
cis-1,3-Dichloropropene	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
trans-1,3-Dichloropropene	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
Ethylbenzene	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
2-Hexanone	ug/l	<17000	U	17000	<20000	U	20000	<17000	U	17000	<33000	U	33000	<17000	U	17000	<10000	U	10000			
Methylene Chloride	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	3900	U	1000			
4-Methyl-2-pentanone	ug/l	<17000	U	17000	<20000	U	20000	<17000	U	17000	<33000	U	33000	<17000	U	17000	<10000	U	10000			
Styrene	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
1,1,2,2-Tetrachloroethane	ug/l	1700		1700	2000		2000	2300		1700	2400	J	3300	1600	J	1700	1300		1000			
Tetrachloroethene	ug/l	12000		1700	16000		2000	1700		1700	85000		3300	59000		1700	53000		1000			
Toluene	ug/l	400	J	1700	350	J	2000	400	J	1700	1100	J	3300	760	J	1700	710	J	1000			
1,2,4-Trichlorobenzene	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
1,1,1-Trichloroethane	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
1,1,2-Trichloroethane	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
Trichloroethene	ug/l	4500		1700	4900		2000	4700		1700	21000		3300	14000		1700	14000		1000			
Vinyl Chloride	ug/l	<1700	U	1700	<2000	U	2000	<1700	U	1700	<3300	U	3300	<1700	U	1700	<1000	U	1000			
Xylenes, Total	ug/l	<3300	U	3300	<4000	U	4000	<3300	U	3300	<6700	U	6700	<3300	U	3300	<2000	U	2000			

		sys_loc_code:			NZVI-4 01/30/2007			NZVI-4 02/28/2007			NZVI-4 05/02/2007			PZ-6B-U 09/24/2006			PZ-6B-U 12/12/2006			PZ-6B-U 12/19/2006		
Parameter	Units	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL
<b>Volatile Organic Compounds</b>																						
<b>Natural Attenuation Parameters</b>																						
Acetylene	ug/l	40	0.5		81	0.5		37	0.5											8.9	0.5	
Methane	ug/l	99	0.1		120	0.1		120	0.1		84	0.1								73	0.1	
Ethane	ug/l	1100	J	0.25	620	0.12		390	J	0.12	0.37	0.025								3	0.025	
Ethene	ug/l	90	0.025		100	0.025		83	0.025		52	0.025								35	0.025	
Total Suspended Solids	mg/l				22	4		18	4		6	4										
Chloride	mg/l				255	5		258	5		301	5										
Nitrite	mg/l				<0.1	U	0.1	0.68	0.1		0.37	J-	0.1									
Nitrate	mg/l				<0.1	U	0.1	<0.1	U	0.1	<0.10	R	0.1									
Sulfate	mg/l				69.5	1		78.5	1		177	1										
Alkalinity, Total	mg/l				220	J	5	230	5		240	5										
Phosphorus	mg/l					<0.1	U	0.1	<0.1	U	0.1	<0.1	U	0.1								
Sulfide	mg/l					1.3	1	<1	U	1	1.3	1										
Total Organic Carbon	mg/l	90	4		99	4		94	4		130	J+	10	100	2		110	10				
<b>Field Parameters</b>																						
Temperature	deg c	11.4			11.8			13.98			15.7			12.6						12		
Specific Conductance	ms/cm	1.62			1.61			1.36			0.926			2.01						2.14		
pH	pH units	11.3			6.84			6.98			7.42			6.68						6.81		
Turbidity	ntu	2.4			23			29.1			8.9			0.8						0		
Dissolved Oxygen	mg/l	0.56			0.24			0			0			0						0		
Oxidation-Reduction Potential	millivolts	-270			-86			-225			-88			-5						-17		
Ferrous Iron	ppm										2.7											

	sys_loc_code:	PZ-6B-U			PZ-6B-U			PZ-6B-U			PZ-6B-U		
	sample_date:	01/04/2007			01/31/2007			02/28/2007			05/01/2007		
	sys_sample_code:	PZ-6B-U_010407_A7A040267005			PZ-6B-U_013107_A7A310293004			PZ6BU_022807_PA7C010104003			PZ6BU_050107_PA7E020224003		
Parameter	Units	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL	Result	Qual	RL
<b>Volatile Organic Compounds</b>													
Acetone	ug/l	<17000	U	17000	<25000	U	25000	<17000	U	17000	<10000	U	10000
Benzene	ug/l	4800		1700	5600		2500	3300		1700	3800		1000
Bromodichloromethane	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
Bromoform	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
Bromomethane	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
2-Butanone	ug/l	<17000	U	17000	<25000	U	25000	<17000	U	17000	<10000	U	10000
Carbon Disulfide	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
Carbon Tetrachloride	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
Chlorobenzene	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	230	J	1000
Dibromochloromethane	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
Chloroethane	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
Chloroform	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
Chloromethane	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
1,2-Dichlorobenzene	ug/l	14000		1700	17000		2500	12000		1700	11000		1000
1,3-Dichlorobenzene	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
1,4-Dichlorobenzene	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
1,1-Dichloroethane	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
1,2-Dichloroethane	ug/l	<1700	U	1700	1200	J	2500	930	J	1700	<1000	U	1000
1,1-Dichloroethene	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
cis-1,2-Dichloroether	ug/l	26000		1700	29000		2500	22000		1700	22000		1000
trans-1,2-Dichloroethene	ug/l	1700		1700	1800	J	2500	1300	J	1700	1200		1000
1,2-Dichloropropane	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
cis-1,3-Dichloropropene	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
trans-1,3-Dichloropropene	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
E-hylbenzene	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
2-Hexanone	ug/l	<17000	U	17000	<25000	U	25000	<17000	U	17000	<10000	U	10000
Methylene Chloride	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
4-Methyl-2-pentanone	ug/l	<17000	U	17000	<25000	U	25000	<17000	U	17000	<10000	U	10000
Styrene	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
1,1,2,2-Tetrachloroethane	ug/l	1300	J	1700	1400	J	2500	1100	J	1700	1200		1000
Tetrachloroethene	ug/l	46000		1700	54000		2500	38000		1700	27000		1000
Toluene	ug/l	620	J	1700	660	J	2500	480	J	1700	420	J	1000
1,2,4-Trichlorobenzene	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
1,1,1-Trichloroethane	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
1,1,2-Trichloroethane	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
Trichloroethene	ug/l	11000		1700	12000		2500	8500	J	1700	7100		1000
Vinyl Chloride	ug/l	<1700	U	1700	<2500	U	2500	<1700	U	1700	<1000	U	1000
Xylenes, Total	ug/l	<3300	U	3300	<5000	U	5000	<3300	U	3300	<2000	U	2000

**Appendix C**  
**NZVI Pilot Test Analytical Results**

			PZ-6B-U	PZ-6B-U	PZ-6B-U	PZ-6B-U	
			01/04/2007	01/31/2007	02/28/2007	05/01/2007	
			sys_loc_code: sample_date: sys_sample_code:	PZ-6B-U_010407_A7A040267005	PZ-6B-U_013107_A7A310293004	PZ6BU_022807_PA7C010104003	PZ6BU_050107_PA7E020224003
Parameter	Units	Result	Qual	RL	Result	Qual	RL
<b>Volatile Organic Compounds</b>							
Acetylene	ug/l	5.8	0.5	2.2	0.5	1.6	0.5
Methane	ug/l	69	0.1	83	0.1	88	0.1
Ethane	ug/l	4.4	0.025	2.5	0.025	2.7	0.025
Ethene	ug/l	33	0.025	41	0.025	39	0.025
Total Suspended Solids	mg/l	7	4			5	4
Chloride	mg/l					395	5
Nitrite	mg/l	0.16	0.1			<0.1	U 0.1
Nitrate	mg/l	<0.1	U 0.1			<0.1	U 0.1
Sulfate	mg/l	161	1			163	1
Alkalinity, Total	mg/l	250	5			250	J 5
Phosphorus	mg/l	<0.1	U 0.1			<0.1	U 0.1
Sulfide	mg/l	<1	U 1			<1	U 1
Total Organic Carbon	mg/l	120	10	120	10	120	4
<b>Field Parameters</b>							
Temperature	deg c	17		12		12.1	14.11
Specific Conductance	ms/cm	2.05		2.08		2.16	1.89
pH	pH units	7.13		8.06		6.96	6.9
Turbidity	ntu	0		0		11.8	10.1
Dissolved Oxygen	mg/l	0		0.42		0.25	0
Oxidation-Reduction Potential	millivolts	-84		-88		-34	-79
Ferrous Ion	ppm						

